Control ENGINEERING

INSTRUMENTATION AND CONTROL SYSTEMS

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DECEMBER 1960

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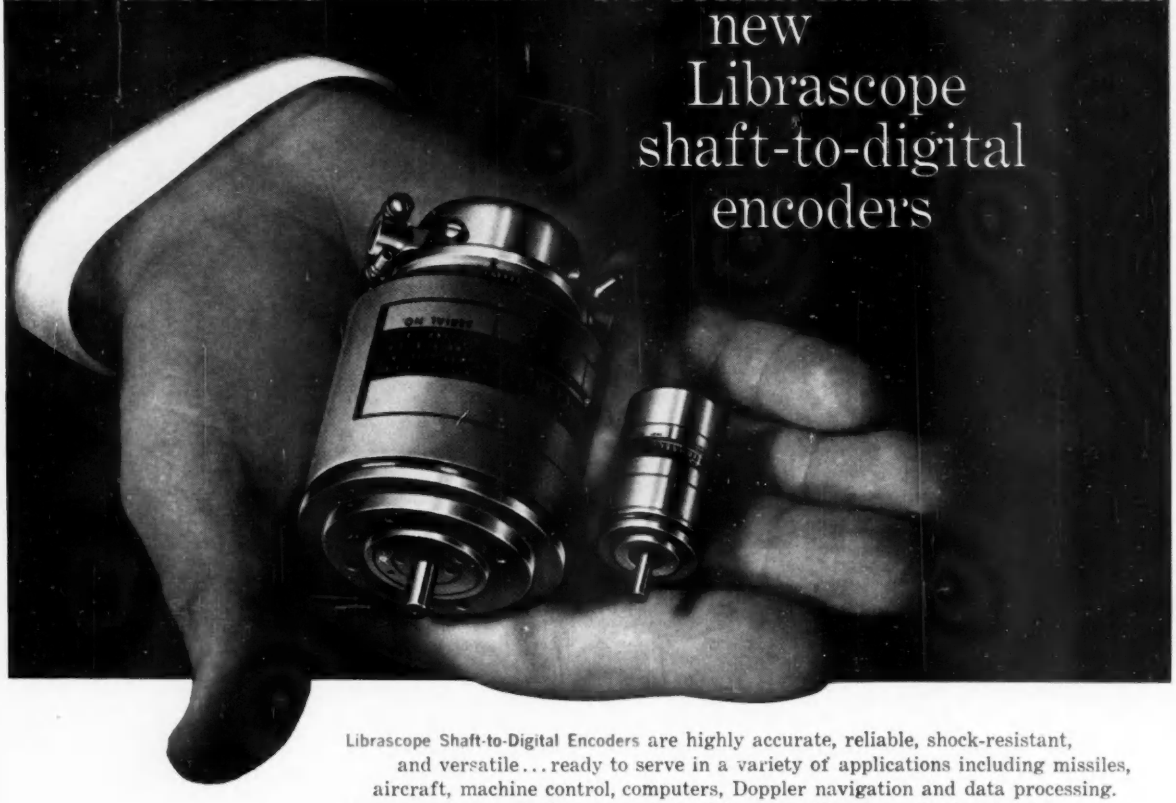
new Librascope shaft-to-digital encoders



Librascope Shaft-to-Digital Encoders are highly accurate, reliable, shock-resistant, and versatile... ready to serve in a variety of applications including missiles, aircraft, machine control, computers, Doppler navigation and data processing. Accuracy that counts is the by-word of a Librascope Encoder... backed by the superior technology and reputation of one of the world's largest producers of *Computers that Pace Man's Expanding Mind.*

new noncontact magnetic encoder

MODEL NO. 807

FEATURES:
Long life, high reliability, high speed, natural binary V-Scan readout.

SPECIFICATIONS:
Output Code: natural binary
Resolution: (per input shaft turn) 128 counts
Full Scale Capacity: 7 bits*
Speed: operating from 0 to 10,000 rpm
Life Expectancy: 20,000 hours at 4,000 rpm; 4 x 10^9 revolutions
Starting Torque: 0.1 in-oz. max.
Diameter: 2"
Length: 1 13/16"
Weight: 5 ounces

*ALSO AVAILABLE IN 13, 17, AND 19 BIT CAPACITIES.

new subminiature size 8 encoder

MODEL NOS. 787 & 793

FEATURES:
Low torque, low inertia, long life, high reliability, withstands severe environments.

SPECIFICATIONS:
Output Code: natural binary
Resolution: (per input shaft turn) 128 counts
Full Scale Capacity: 7 bits, 13 bits
Speed: operating 200 rpm, slew 600 rpm
Life Expectancy: 2 x 10^6 revolutions at 200 rpm
Starting Torque: 0.5 oz-in. maximum
Diameter: .750"
Weight: 3 ounces

other popular Librascope encoders

Code	Model no.	Full scale capacity	Resolution per input shaft turn
Binary	773	13 bits	128 counts
	0-773	oil-filled unit for increased life	
Binary	710	10 bits	1024 counts
Binary	707 (707D*)	7 bits	128 "
	713 (713D*)	13 bits	128 "
	717 (717D*)	17 bits	128 "
	719 (719D*)	19 bits	128 "
	0-713	oil-filled unit for increased life	
Self-Decoding Binary	740	10 bits	1024 counts
B/C/D	723 (723D*)	2,000 counts	200 "
	724 (724D*)	20,000 "	200 "
	733 (733D*)	3,600 "	200 "
	734 (734D*)	36,000 "	200 "
	735	360,000 "	200 "
Sine/Cosine	757-S**	4 quadrants per turn	7 bits per quadrant + limit 1
	758 758-S**	4 quadrants per turn	8 bits per quadrant + limit 1
Gray	708	8 bits	256 counts

*Contain isolation diodes for multiplexing **Servo driven, hermetically sealed

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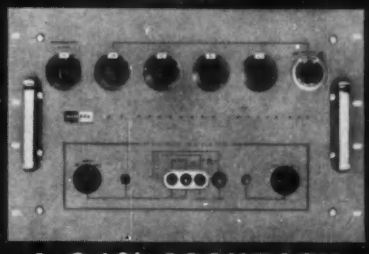

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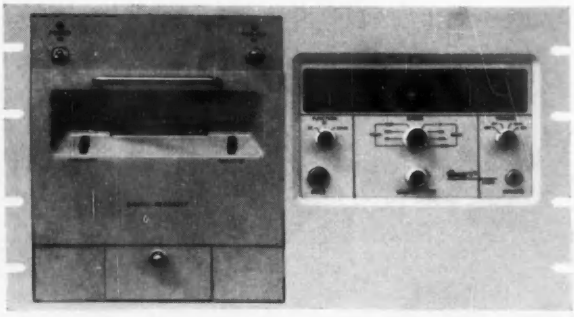

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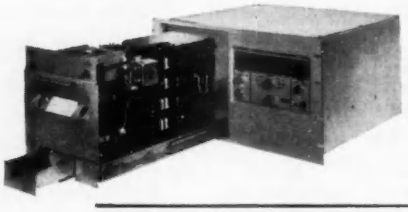

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Control ENGINEERING

DECEMBER 1960
VOL. 7 NO. 12

Published for engineers and technical management men who are responsible for the design, application, and test of instrumentation and automatic control systems

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IDEAS AT WORK

WHAT'S NEW IN THE CONTROL FIELD

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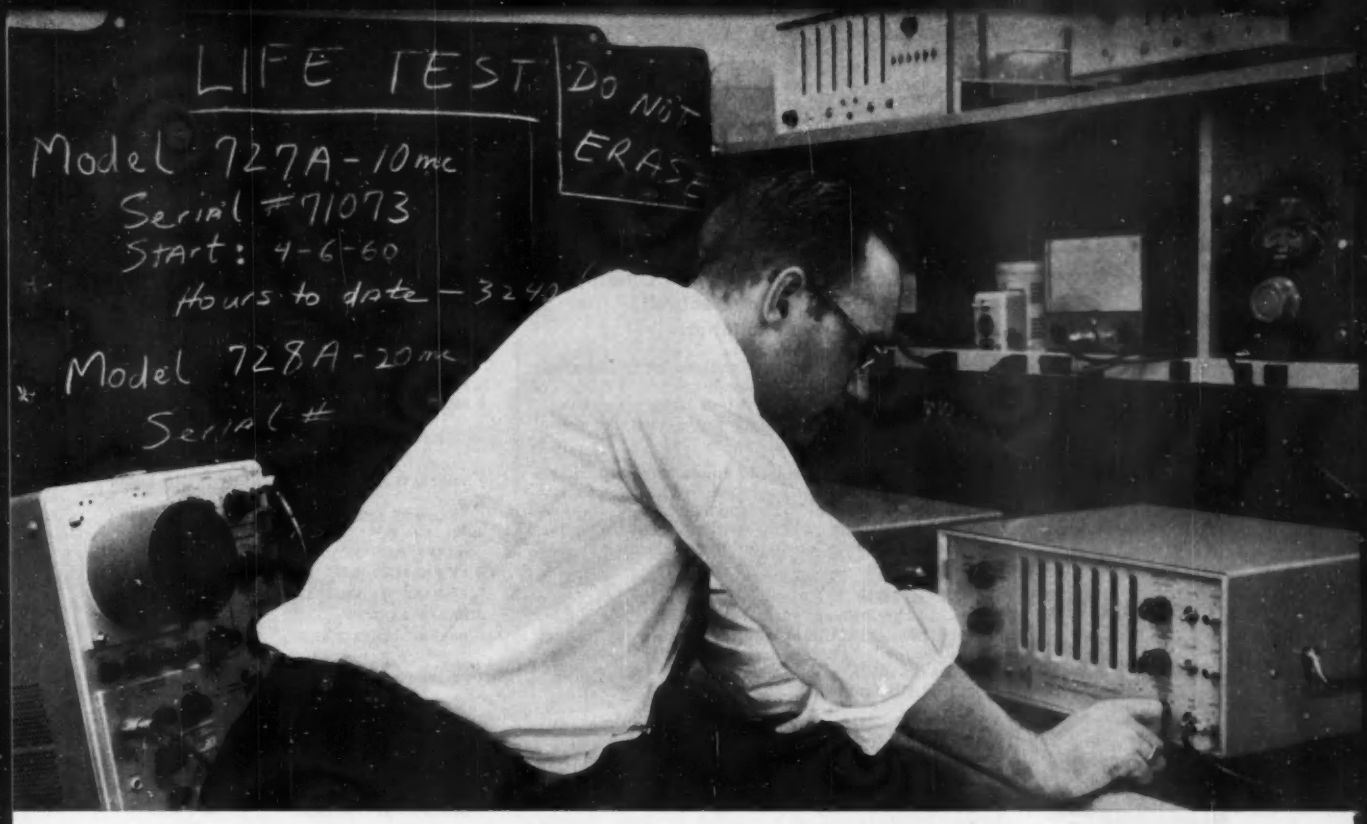

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when CMC counters with solid state reliability cost so little more?

Announcing the CMC 728A
A SOLID STATE 20 MC UNIVERSAL COUNTER-TIMER

Introduction of the CMC 728A marks another frequency step-up from the company that brought you the first transistorized universal counter-timers. CMC, the leader in truly advanced counting, timing, and frequency measuring equipment offers 100 kc, 250 kc, 1 mc, 10 mc and now 20 mc all solid state instrumentation.

	Most Popular 10 mc Vacuum Tube Counter	CMC Solid State 10 mc Counter
Base Price	$2,300	$2,750
Printer Output	75	n/c
Time Interval Section	175	n/c
Total	$2,550	$2,750
Weight	118 lbs.	27 lbs.
Size	21⅛"H x 20"W x 23½"D	7"H x 17"W x 13"D
Power Requirements	600 watts	46 watts
Accuracy	± 1 count ± crystal stability	± 1 count ± crystal stability
Remote Programming	not available	Standard option
Warranty	1 year	2 years
Time Interval Measurements	1 μsec to 10^7 sec in 1 μsec increments	0.1 μsec to 10^7 sec in 0.1 μsec increments
Period Measurement	0 cps to 10 kc	0 cps to 3 mc
Gate Times	0.001, 0.01, 0.1, 1.0 & 10 sec	0.000001 to 10 sec in decade steps
Time Base	10 to 1 multivibrator type	decade dividers – no adjustment

Can You Afford To Settle For Less? If you are considering any counter, will your engineering judgement and sense of *real* economy dictate purchase of old fashioned equipment? Stop and look at the merits of solid state counters. Did you know that the reliability of all CMC solid state counters is backed with a 2 year warranty – double the guarantee of tube counters? Did you know CMC's solid state 10 mc universal counter timer only costs $200 more than comparable vacuum tube counters? That's the beginning. Compare the rest of these specifications.

Compare the 20 mc Solid State Universal Counter-Timer – We'd like to, but frankly, there aren't any comparable vacuum tube counters. This might lead the discerning engineer to think that at 10 mc, vacuum tubes are driven "hard", right to their capacity. *And he'd be right.*

More Information – For complete technical information on high reliability solid state counting instrumentation, call your nearby CMC engineering representative, offices in 33 cities throughout the U.S. and Canada, or write directly to Dept. 21.

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Control ENGINEERING

DECEMBER 1960 VOL. 7 NO. 12

Published for engineers and technical management men responsible for the design, application, and test of automatic control systems

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Further, Sylvania Counter Tubes feature 6 "add-subtract" capabilities, 7 low power requirements, 8 comparatively low cost. They offer 9 improved performance under standby operation, 10 reliable long life. (As assurance, large samples are tested under standby conditions, thermal and mechanical shock conditions, and cycled life operation.)

Have a design problem? Count on your Sylvania Sales Engineer for full data and engineering assistance. For the informative Decade Counter Tube Handbook, contact your Sylvania Industrial Tube Distributor or enclose 15¢ to Electronic Tubes Division, Sylvania Electric Products Inc., Dept. 1312, 1100 Main St., Buffalo 9, N. Y.

Sylvania Types	Total Anode Current (mA) Min.	Max.	Min. Anode Supply Voltage (Vdc)	Min. Double Pulse Amplitude (V)	Min. Double Pulse Width (μsec)
(0-4KC)					
6478(T-11) 6802(T-9) 6879(T-5½)	0.3	0.6	350	—75	60
(0-100KC)					
6909(T-9) 6910(T-11) 7155(T-5½)	0.6	0.8	400	—85	4

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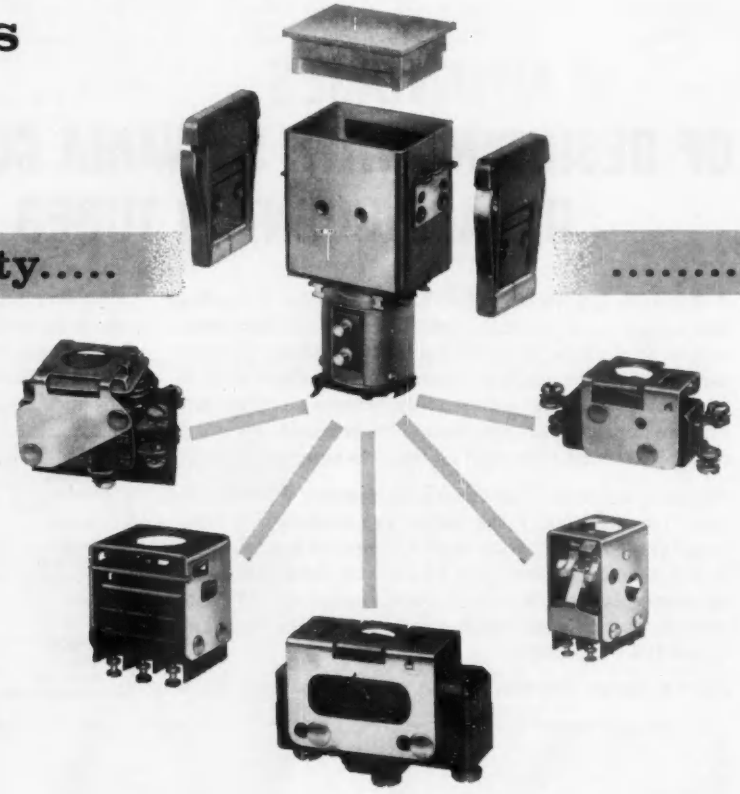

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75 YEARS HONEYWELL PIONEERING THE FUTURE

SHOPTALK

Information systems in retrospect

For several years it has been apparent that the information processing function in control systems was on the rise. Individual control loops have been coordinated by on-line control computers in the processing industries; machine tools, rolling mills, and other manufacturing machinery have been controlled by numerical programmers and on-line computers, and data accumulation has become more prevalent; missile control and ground support systems and defense intelligence nets all have high information handling equipment content—the list could go on and on. But these are now history; what does the future hold?

Information systems in the future

The editors of CONTROL ENGINEERING foresee the interconnection of automatic unit operations (machine tools, materials handling systems, automatic inspection systems) by production monitoring and control systems; they foresee the coordination of several processes and plants based on such factors as raw materials cost, processing efficiency, and transportation alternatives; and they foresee a more direct influence of business decisions on production planning and of production performance on business decisions. But the question is: What do these developments mean to CONTROL ENGINEERING and our readers? As these operations become mechanized and more automatic, a common denominator springs up through the medium of the techniques and equipment of automatic information transmission, automatic information processing, and automatic information display. These are areas where the control engineer's knowledge of automatic control, computation, and decision making will serve him well. This knowledge will make him the key figure in applying information systems to control.

Information systems in Control Engineering

To adequately serve this expanding portion of control engineering technology, all future issues, starting with January 1961, will include a special feature department devoted to the techniques, equipment, application, and theory of information handling systems as they relate to control, whether the system is physically connected to the process (as a data accumulator would be) or whether humans close the loop (as in the generation of business decisions). This new department, plus backup coverage in What's New, New Products, Ideas at Work, etc., will be *in addition to* our regular established coverage. Associate Editor Ed Kompass will bear the responsibility of keeping CtE's readers abreast of developments in this area of control technology with which they will be increasingly concerned.

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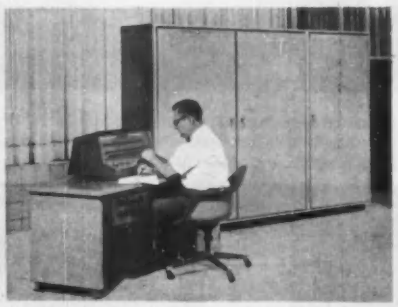

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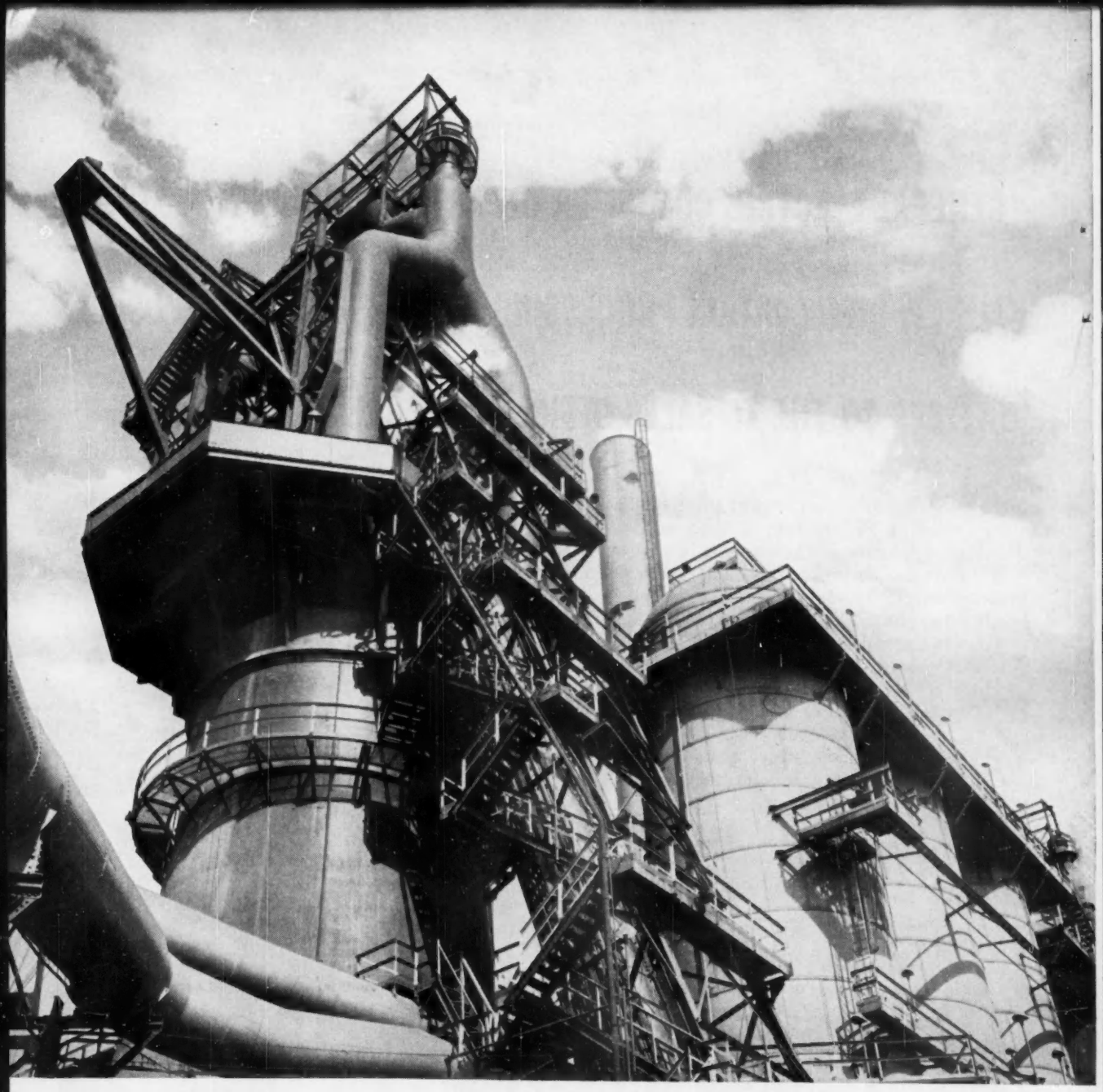
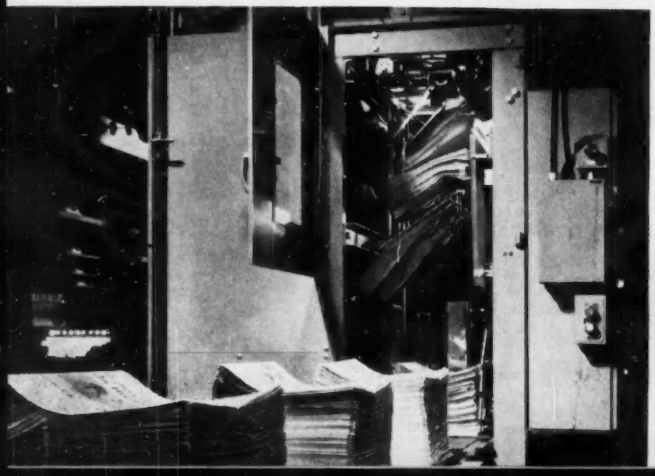


No more hand stacking. This newspaper counter-stacker counts and stacks newspapers automatically—and can be programmed to automatically vary the stacks to meet route schedules.



No more dry pumping. Cutler-Hammer's new development—an automatic pump off control for stripper oil wells—stops the pump when oil has been lifted. Saves the pump, ups production.

FEEDBACK

Adaptives should optimize economics.

TO THE EDITOR—

I have read Prof. Gibson's article on the adaptive principle (Aug. '60) with considerable appreciation and interest. The criticism here offered concerns his omission of an economic criterion for optimization in his otherwise extensive discussion of figures of merit. We all recognize that the only satisfactory basis for optimization is economic, whether explicitly and quantitatively, or whether only implicitly in the nature of the criterion chosen. I readily admit that a complete assessment of all economic factors is seldom possible for accurate economic optimization, but I do think we should recognize, in principle, that IRAR (impulse response area ratio) and other such criteria are only halfway stages toward this end.

To be specific, it helps to divide costs of any system into:

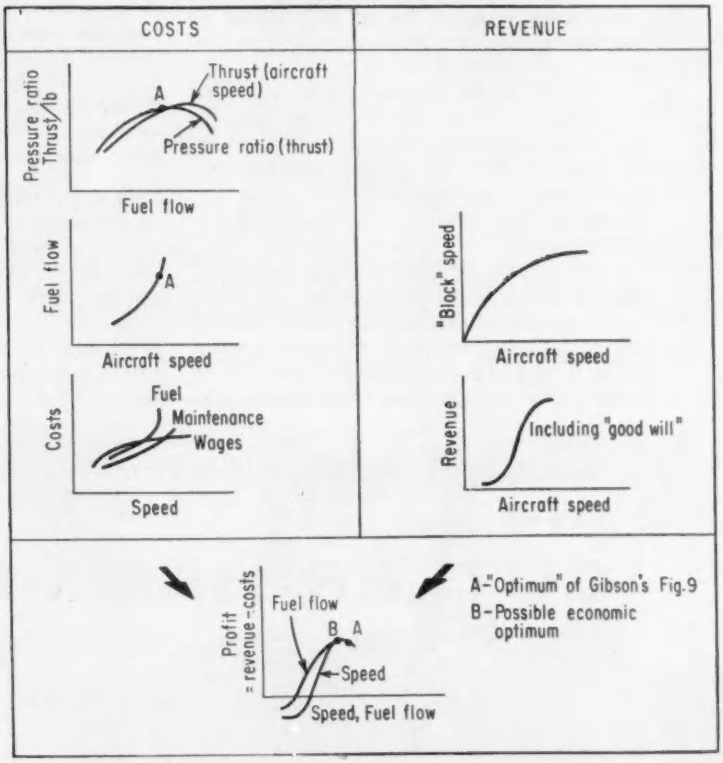
(a) the expense functions
(b) the revenue functions, including good-will, or its negative, a penalty functon due to imperfect performance.

An optimizing or adaptive system should monitor parameter(s) of the system so that operation occurs at least penalty, or maximum profit, etc.

As an example of this thinking, consider Prof. Gibson's example of optimizing jet engine performance. Changing the fuel flow, and hence pressure ratio, changes the aircraft revenue, possibly as shown in my figure. Similarly, the operating costs (fuel, wages, etc.) of the aircraft change. Hence an economically-based adaptive control would maximize the difference between revenue and costs, point *B* in my figure. This would not necessarily be the point of maximum pressure ratio A. A computed modification of the pressure ratio signal might permit the circuit of Prof. Gibson's Fig. 12 to approximate the economic optimization.

I admit the present difficulty of gathering adequate information but plead for acceptance of the principle of economic optimization in our thinking. Such thinking has long been qualitatively applied by business management and is now being quantita-

BASIS OF ECONOMIC OPTIMIZATION



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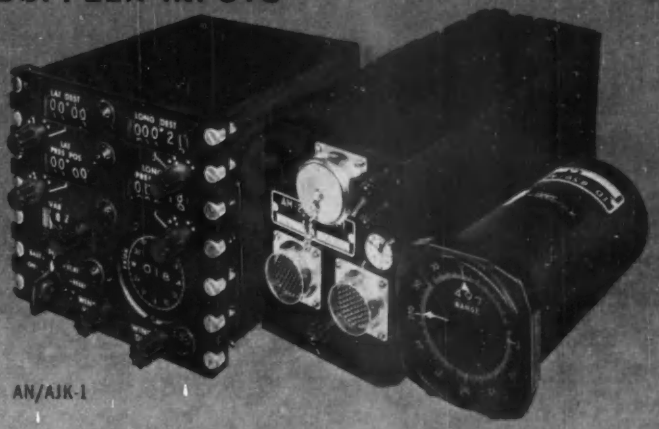

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FEEDBACK

tively applied through operations research (linear programming, etc.) and more recently through process control by computers.

J. H. Milsum
National Research Council
Ottawa, Canada

You're so right, but:

To the Editor—

Dr. Milsum is entirely correct that the figures of merit I discussed are only half-way stages toward the ultimate economic criteria. He also hits the mark with his summary. Indeed it is difficult to establish economic goals in functional language that may be used by the system. It will probably be necessary to separate short term goals from long term goals, as business does today. The middle level manager must show a profit each year. Constraints are presumably placed upon him, however, by upper level management due to their (perhaps?) somewhat different goals of long term growth and continuing profit.

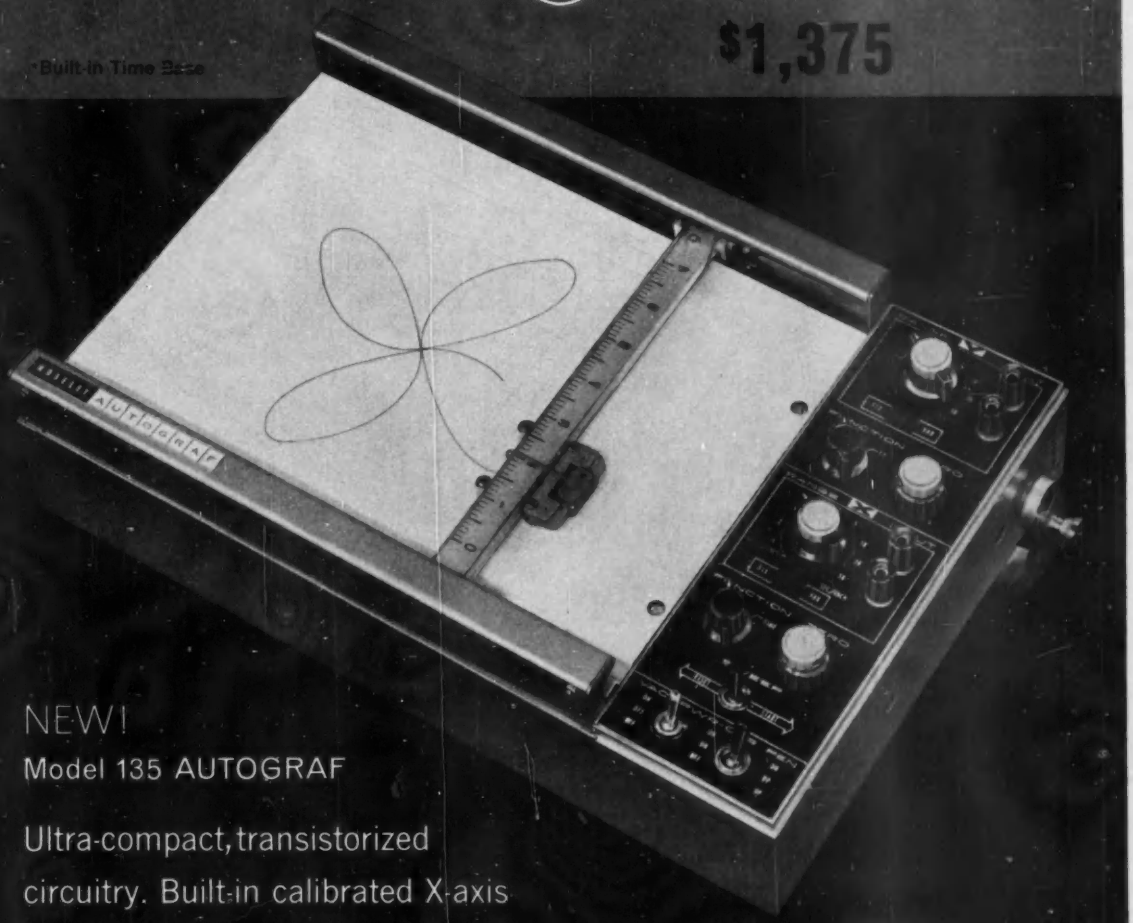
R. Bellman (Dynamic Programming, Princeton University Press, 1957) has moved one step in the right direction with an index of performance made up by summing two parts. The first part is a function of the error of the system and thus conforms to the indices discussed in my article. The second part, however, is a function measuring the cost of control, that is, the cost of the deviation of the system from its optimum. An accurate determination of this function may be very difficult in any given case but is obviously worthwhile.

Our research in adaptive controls at Purdue has emphasized the concept of the index of performance or figure of merit for several reasons. First, it forces the designer to be explicit about exactly what he wants from his control systems. This is a difficult question, of course. Second, it is obvious that no system can be better than its index of performance. We are beginning work on systems that modify their own indices of performance in the light of operating experience. In a sense it might be said then that these devices will exhibit certain aspects of learning. Certainly an economic criterion could be incorporated in such a device.

John E. Gibson
Purdue University
Lafayette, Ind.

World's Most Compact, Lightweight 8½" x 11" XY-(T)* RECORDER: $1,375

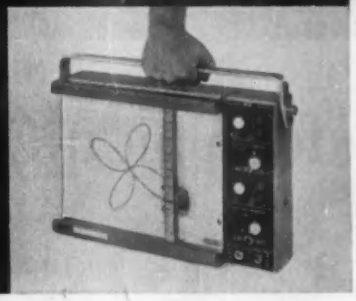
*Built-in Time Base



NEW!
Model 135 AUTOGRAF

Ultra-compact, transistorized circuitry. Built-in calibrated X-axis time sweeps, 16 calibrated ranges (each axis) plus stepless range control. Portable, rack or table mount, 10½" x 16⅛" x 4½", weighs only 20 lbs.! Includes all popular AUTOGRAF features for maximum usefulness, versatility.

Data and price subject to change without notice



AUTOGRAF *recorders*

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MUrray 1-0208 Cable MOCOPAS
Field representatives in all principal areas

6946

Typical control panel at Union Carbide's Institute Plant has over 100 Foxboro Consotrol* indicators, recorders, and controllers.

for Union Carbide's Institute Plant...rapid,

A sprawling chemical metropolis, stretching as far as the eye can see. That's Union Carbide Chemicals Company's Institute, West Virginia plant — producer of Ucon† Fluorocarbon propellants and refrigerants.

Foxboro instrumentation is used to help control 20 of the different processing units at the Institute Plant. Over 10,000 Foxboro indicators, controllers, recorders, and transmitters are used, as well as thousands of Foxboro control valves.

Union Carbide reports favorably on their Foxboro instruments. "In general, we find them easy to work on, easy to repair, easy to maintain." And the company adds, "we appreciate the ability of the Foxboro engineers who work with us."

*Reg. U. S. Pat Off.
† Trade-mark of Union Carbide Corp.*

Process is hydraulic — requires fast, sensitive instrument response.

sensitive Foxboro control

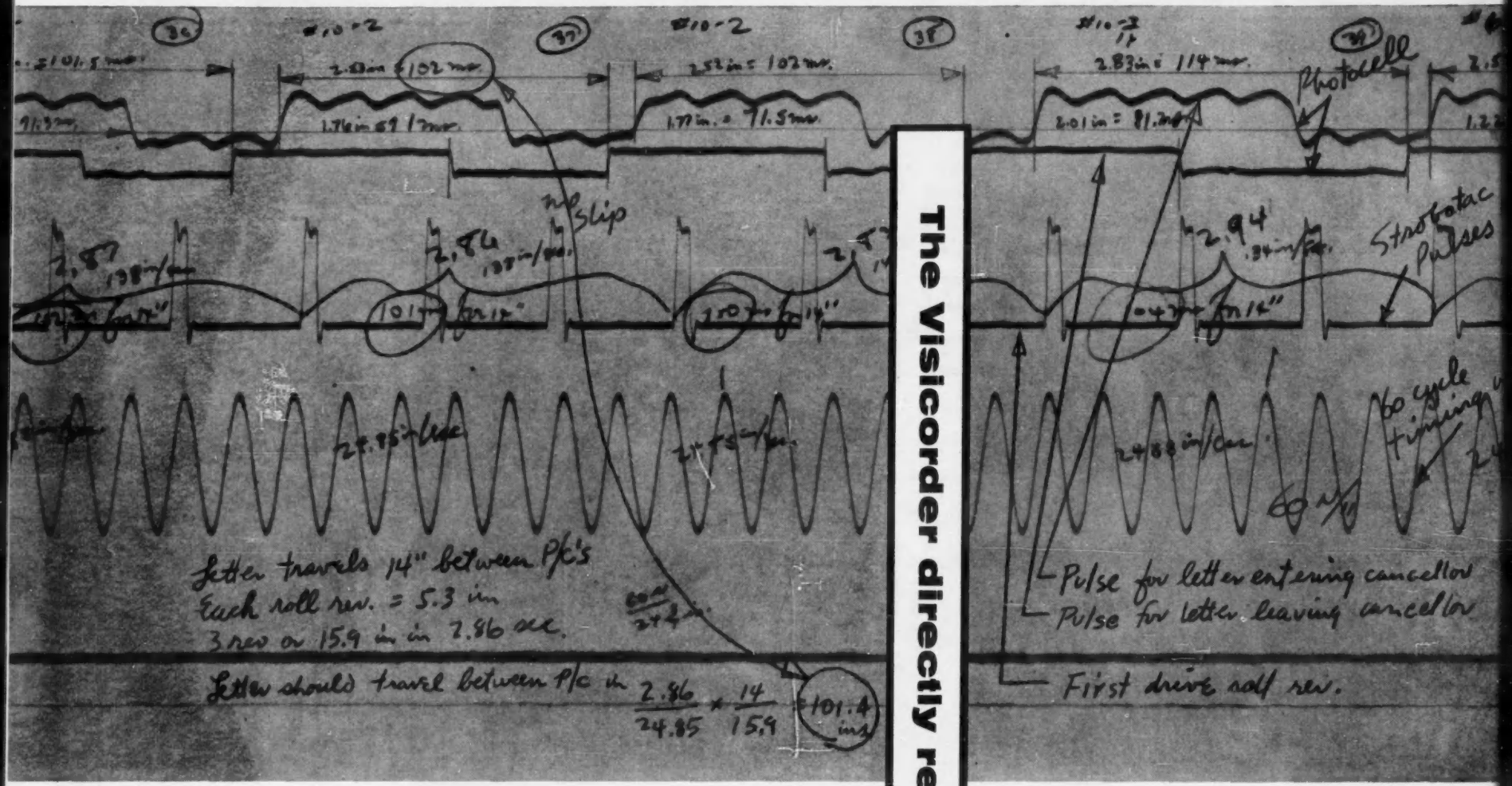
You'll like working with Foxboro, too. Unsurpassed instrumentation, both pneumatic and electronic; unsurpassed engineering and service. Ask your local Foxboro Field Engineer for the complete story. Or write for Bulletin 13-18. The Foxboro Company, 8512 Neponset Avenue, Foxboro, Massachusetts.

FOXBORO

REG. U.S. PAT. OFF.

Lab analysis is done right in the control room of this Carbide processing unit. Necessary process adjustments can be made on Foxboro controllers the minute technician detects the need.

CIRCLE 21 ON READER SERVICE CARD



Unretouched Honeywell Visicorder record, actual size.

The Visicorder directly records

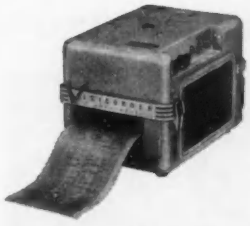
The Emerson Research Laboratories at Washington, D.C., directly-recorded this chart on a Honeywell Model 906 Visicorder. The chart shows a canceller test of a number of letters through a new mail-handling machine developed by Emerson for the U.S. Post Office Department.

In this test, the Visicorder took only 3 hours to reveal information that would have taken 3 weeks to get by any other means: what factors were responsible for the changing speeds of letters as they traveled through the machine at the rate of 30,000 letters per hour. Constant letter-travel speeds were necessary in order to register the cancellation mark on the stamp every time.

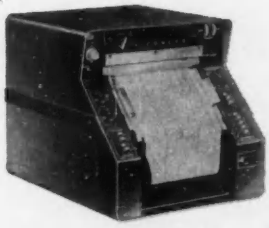
This Visicorder record revealed that motor speed variations, belt slippage and slippage of the letter in the drive rollers were responsible. A synchronous drive motor, a timing belt drive and a better grade of rubber in the drive rollers were added to solve the problem—at a vast saving in engineering time.

Milton Stovall, Emerson Project Engineer, uses the Visicorder to measure roller bounce caused by various letter thicknesses, and the consistency of letter speed through the new Emerson Automatic Mail Cancelling and Facing Machine.

high-speed letter travel



Recent Models of the 906 Visicorder incorporate time lines and grid lines and record up to 14 simultaneous channels of data.



The NEW Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.

The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

No matter what field you are in . . . research, development, computing, rocketry, product design, control, nucleonics . . . the high-frequency (DC to 5000 cps) Visicorder Oscillograph will save you time and money in data acquisition.

Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: write for Bulletins 1108, 1012, and HC906B

Minneapolis-Honeywell Regulator Co.
Industrial Products Group, Heiland Division
5200 E. Evans Avenue, Denver 22, Colorado

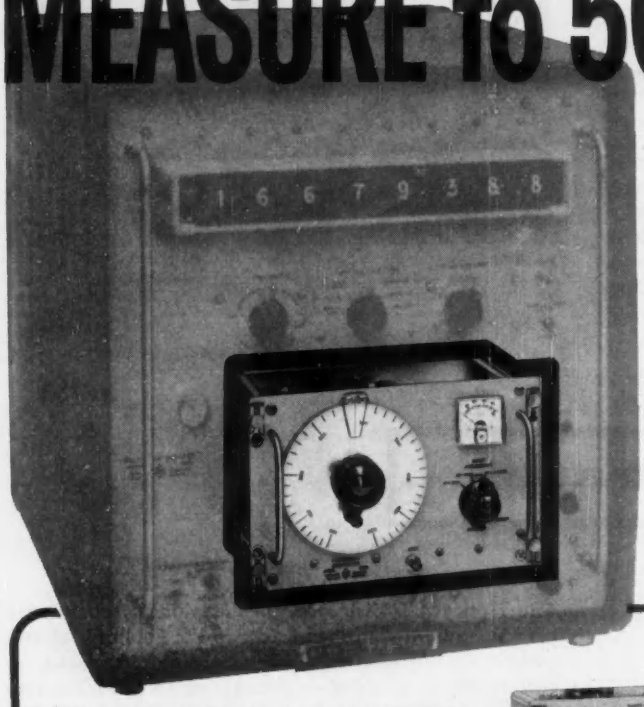
75th YEAR PIONEERING THE FUTURE

Honeywell

Industrial Products Group

This new, inexpensive hp plug-in lets you

MEASURE to 500 MC - with

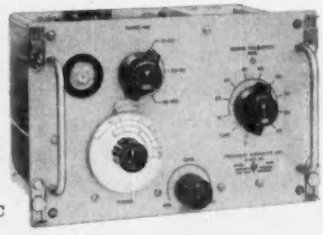


Simple operation with plug-ins—high sensitivity—ideal for telemetering, mobile, production, general purpose measurements

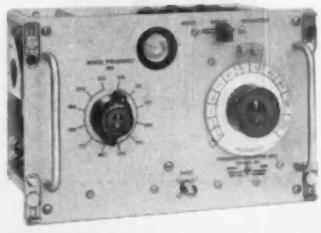
Now hp offers a completely new, 500 MC plug-in — materially improving the versatility and usefulness, as well

Still more versatility for 524 series counters! Order the measuring capability you need now—later add other plug-ins to increase counter usefulness.

hp 525A Frequency Converter
$250.00, extends counter range to 100 MC



hp 525B Frequency Converter
$250.00, extends range to 220 MC



hp IS HEADQUARTERS FOR ELECTRONIC COUNTERS

Standard of the industry for frequency, period, phase and time interval measurement — accurate, dependable, versatile, economical!

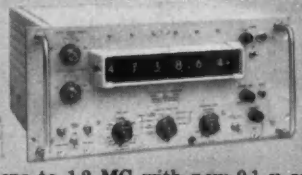
hp 524C/CR ELECTRONIC COUNTERS (shown above)

Measure to 10.1 MC individually, to 500 MC with plug-ins, to 18 KMC with external accessories*. The hp 524C/CR also measures time interval 1 μsec to 100 days or period 0 cps to 100 KC, automatically, directly, without tedious calculation or interpolation. Big, bright in-line readout. Maximum resolution 0.1 μsec; stability $3/10^8$ short term and $5/10^8$ per week. High sensitivity, high impedance, hp 524C (cabinet — shown above) $2,300.00; hp 524CR (rack mount) $2,275.00.

hp 524D/DR Electronic Counter

Offers electronic features identical to those of hp 524C/CR except that it has eight-place neon columnar readout. hp 524D (cabinet) $2,150.00; hp 524DR (rack mount) $2,125.00.

with hp 540B Transfer Oscillator and hp P932A Waveguide Mixer



hp 523CR ELECTRONIC COUNTER

10 cps to 1.2 MC with new 0.1 v sensitivity. Bright in-line readout. Measures time interval 1 μsec to 10^6 sec and period 0.00001 cps to 100 KC and phase angle. Stability $2/10^6$ per week. Improved circuitry prevents triggering by unwanted signals, noise. Results appear in seconds, msec, μsec or KC with automatic decimal. hp 523CR (rack mount) $1,485.00.

hp 523DR Electronic Counter

Offers electronic features identical with those of hp 523CR but has six-place neon columnar readout. hp 523DR (rack mount) $1,285.00.

COUNTER ACCURACY!

as frequency range, of popular hp 524 series 10 MC electronic counters.

Combined with the hp 524C 10 MC counter, for example, the 525C plug-in offers measurement with high sensitivity to 500 MC yet retains measurement accuracy and even increases resolution at high frequencies. Also preserved are 524C measuring ease, digital recorder output capability and its big, bright in-line display.

Specifications hp 525C

Range: Counter converter, 100 to 500 MC; counter amplifier, 50 KC to 10.1 MC. Direct connection for 0 to 10.1 MC.

Accuracy: Retains accuracy of 524 Counter.

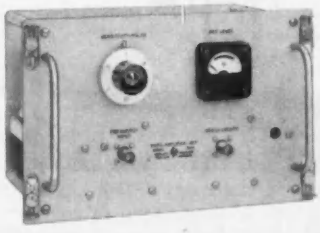
Registration: 9 places, 1st two on converter dial, next 7 displayed by counter.

Input Voltage: 20 mv rms min., 50 KC to 10.1 MC; 100 mv rms min., 100 to 500 MC.

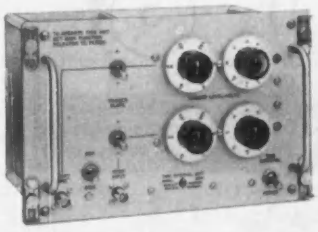
Input Impedance: Approx. 700 ohms, 50 KC to 10.1 MC. Approx. 50 ohms, 100 MC to 510 MC.

Price: hp 525C, $425.00.

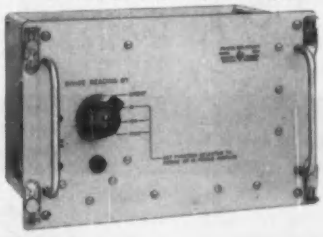
hp 526A Video Amplifier
$175.00, increases sensitivity to 10 mv



hp 526B Time Interval Unit
$175.00, for time interval measurement 1 μsec to 10^7 sec.



hp 526C Period Multiplier
$225.00, increases period measuring accuracy with 100, 1,000, 10,000 cycle multiples



hp 522B/BR ELECTRONIC COUNTER

Popular hp 522B/BR measures frequency 10 cps to 120 KC, period 0.00001 cps to 10 KC, time interval 10 μsec to 10^5 sec. Reads direct in cps, KC, seconds, milliseconds. Time base stability $1/10^5$ per week; counts automatically, resets, action repetitive. Applications include measurement of production line quantities, nuclear radiation, power line frequencies, very low frequencies, and, with transducers, a wide array of physical quantities and phenomena. hp 522B (cabinet) $915.00; hp 522BR (rack mount) $900.00.

hp 521 INDUSTRIAL COUNTERS

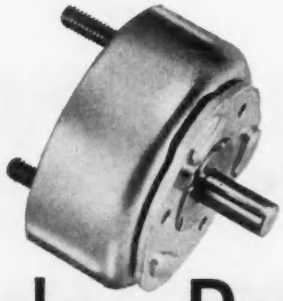
hp offers five Model 521 counters, all useful in measuring frequency, random events per unit of time, and, with transducers, speed, rps, rpm, weight, pressure, temperature, etc. Direct readings, display time variable or "hold"; four instruments cover frequency range 1 cps to 120 KC; the fifth measures to 1.2 MC. Two models with big, bright, in-line numeric readout, three with columnar neon display. Prices, $475.00 to $875.00. Cabinet and rack mounts available.

Data subject to change without notice. Prices f.o.b. factory.

See your nearest hp representative or write direct for information, demonstration of any hp electronic counter.

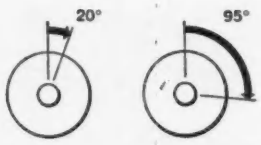
HEWLETT-PACKARD COMPANY
1053K Page Mill Road Palo Alto, California, U.S.A.
Cable "HEWPACK" DAvenport 6-7000
Sales representatives in all principal areas

HEWLETT-PACKARD S. A.
Rue du Vieux Billard No. 1 Geneva, Switzerland
Cable "HEWPACKSA" Tel. No. (022) 26. 43. 36



Ledex Rotary Solenoid

BASIC INFORMATION



Standard Ledex Rotary Solenoids will provide rotary strokes from 20° to 95°.

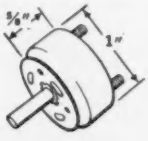
Action is snap-type, with spring return to starting position after completing stroke.

Action is instantaneous, approx. 1/30 sec. for 35° stroke and return.

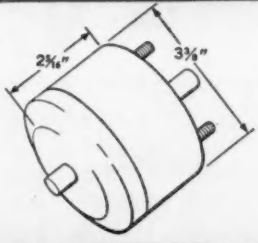
Available in left hand stroke as well as right.

Standard Rotary Solenoids provide torque almost equal throughout stroke. Higher starting torque models can be designed.

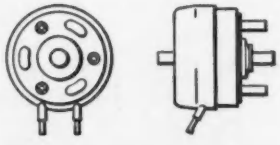
Will also provide powerful, highly efficient, short stroke piston action.



Smallest in size #1, have weight 1½ oz., torque up to .8 pound inches.



Largest in size #5, have weight 4 lbs. 9 oz., torque up to 98 pound inches.



Standard power take-offs include armature pins with three tapped holes and shaft extension from either or both ends. Special designs available.

The Ledex Method of actuation and control gives instantaneous high-torque-to-size rotary motion and high-thrust-to-size piston motion, for reliable remote mechanical actuation or remote control of rotary-type switches.

The efficient Ledex Rotary Solenoid is the heart of this method. Available in 8 compact sizes, with operating voltage from 3 to 300 V.D.C. Over 240 stock models ready for immediate shipment. Used in thousands of applications including valves, tape recorders, waveguide switches, sorting equipment, gyrocaging, computers, wireless teletypes, vending machines, typesetters, missile guidance and ground support equipment.

Other Ledex Method products are Syncramental Stepping Motors, Rotary Stepping and Selecting Switches. Write for Bulletin A-1259, mentioning application, to Ledex Inc., Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.; NSF GmbH, Nurnberg, Germany.

LEDEX®

High-torque-to-size rotary motion
High-thrust-to-size piston motion

R. H. Eisengrein
points a tool builder to control

Squeezed into the narrow confines of an Navy gun turret during World War II—maintenance manual schematic propped up at his side—General Electric troubleshooter R. H. Eisengrein carefully checked out the circuitry of the turret and gun director. As he followed the peregrinations of these pioneering automatic systems, with their wiring complexity and multiplicity of components, he wondered about the men who designed them, determined to be a control designer himself someday. Eighteen years later he can look back on a career in control that has carried him through automatic aircraft systems into the demanding industrial control field. Today, as vice-president of the Electronics Div. of Seneca Falls Machine Co., Bob Eisengrein is diversifying the one-time conservative machine tool builder into the control field.

Looking at a mechanical power amplifier which Seneca had developed (CtE, July '58, p. 113), Eisengrein saw in it the basis for an entire line of controls. He started searching for possible applications and found the MPA replaced hydraulic systems and dc motors in machine tools and envisioned even more potential for it outside the machine tool business. For example, in one installation, the mechanical amplifier synchronized the rotation of two shafts involved in a TV tube manufacturing process. So great is the market for his controls, says Eisengrein, that he predicts greater Seneca sales in them than in machinery in the near future.

Bob was born in New York City's lost borough, Staten Island, and took the ferry ride across New York harbor each day to earn a BS degree in electrical engineering at Brooklyn Polytechnic Institute, graduating in 1941. He started out at GE with a year on its Test program, then joined the company's Aircraft & Marine Dept. as a service engineer.

After the war ended, Eisengrein realized that he would need more formal training if he was to do what he wanted in control systems engineering. So in 1947 he landed an assistantship at MIT, working in the Servo Lab under Gordon Brown and obtaining his Master's degree in EE in 1949. While at MIT, Bob worked on the advanced fire control system for the B-45 and wrote his thesis around his research into noise in radar systems.

His first chance to use his newly sharpened control talents came when he joined Sundstrand Aviation as chief research engineer. He designed controls for electrical and hydraulic constant speed drives and was introduced to machine tool control when he helped develop a system to trace line drawings of aircraft parts for Sundstrand's Machine Div.

Then in the autumn of 1954, Bob accepted Seneca's bid to set up its controls division. He found himself tackling the two-edged problem of not only designing the company's control systems but also of selling them—often to competing machinery builders. But Eisengrein revels in his combination administration-engineering job. When he goes a little stale doing desk chores, he can still jump into his laboratory's work, "getting his hands dirty" in circuit development. And as evidence that he is still very much an engineer at heart, Bob points to his eight patents, issued in the past 10 years, with the most recent one only a few months old.

Eisengrein finds more enjoyment, however, in selling his controls—because the challenge is greater. First he had to do a selling job on Seneca Falls management. But in return, Bob admits, he and his fellow control proponents have learned that they can't change a whole machine just to accommodate the desires of the control designer. Next came the job of selling other machine tool builders on the idea of buying Seneca controls. And the biggest chore of all has been convincing control buyers in other fields that his MPA-based control units have something to offer in other applications.

Bob feels his machine tool customers should be allowed to stay in the machining business. Seneca designs and builds the machine and its control, doesn't leave the control choice up to the buyer.

Special Works Memo

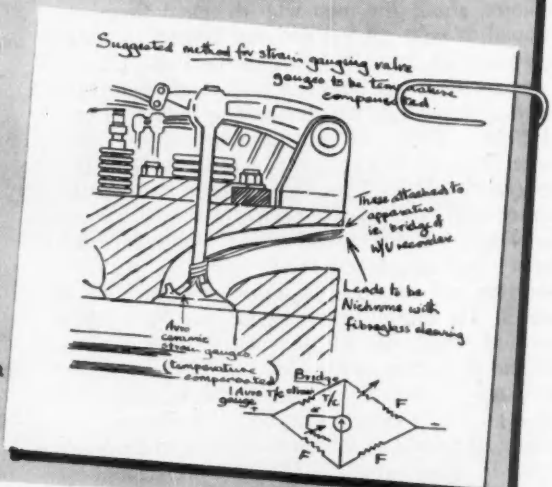
TO Production Engineering and Process Control Depts.

FROM Chief Engineer, Special Projects Division.

Tests have been carried out on two new Armstrong Whitworth Equipment products. Results have been excellent and these items might well be the answer to several of our problems. Preliminary details are:-

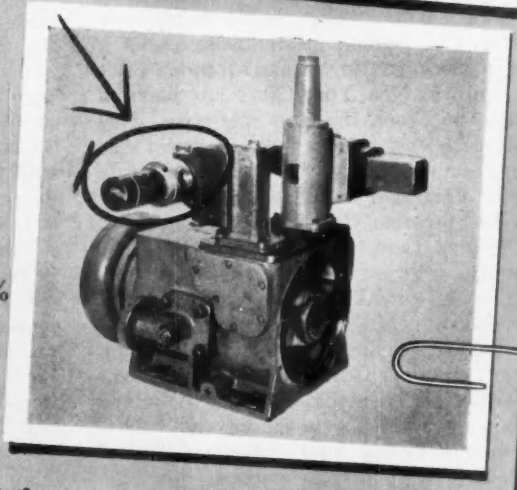
(1) Avro High Temperature Strain Gauges

Strain or minute structural variation measurable accurately at temperatures up to 1,000°C. Transverse resistance cross sensitivity negligible due to rectangular grid section design and stray thermo-electric effects nil. Ceramic cement impregnated non-removable fibrecloth backing bends around small radii. Fixing is by proven adhesives. Illustration shows typical hot point use for gauges. Note that temperature compensating thermo couples may be supplied built into each gauge!



(2) Limited Angle Tacho-Generator

Operates on a 30° angle about a mid position.
Size 1" rotor (2" nominal dia. case 3.75" long). There is also a 3" diameter rotor generator for special order.
Sensitivity 5 volts/radian/sec. ±15%
Load 27 kil-ohms
Frequency response 3 db down at 37 cycles/sec.
Winding resistance 1,680 ohms ±5%
Operating torque 500 gm. cm.
Direct lever drive eliminates gear back lash discrepancies.
Illustration shows use for velocity feed-back measurement on swash-plate pump driving large machine tool.



ARMSTRONG WHITWORTH EQUIPMENT, Hucclecote, Gloucester. Telephone: Gloucester 66781
SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD., MEMBER OF HAWKER SIDDELEY AVIATION

Newsbreaks In Control

● Japan Builds a Wind Tunnel

Tokyo—Previously banned by the terms of the surrender ending World War II, Japanese interest in designing and building aircraft and missiles has been rekindled. Last month the Japanese government completed a Mach 1.4 transonic wind tunnel at its Aeronautic Technology Laboratory of the Japanese Science and Technology Agency. Instrumentation for the blow-down tunnel was built by the U.S.'s Datex Corp.

● Britain Wants That Soviet Business

London—Britain's Board of Trade and 621 British firms will spend $5.6 million to stage a giant trade fair in Moscow next year. Covering a million square feet, it will be the biggest foreign display ever held in the Soviet Union. Over 2,000 British sellers will man the booths, and a 800-page catalog will be prepared for Russian visitors.

● IBM Makes It Official

San Jose—IBM is officially in the process computer control business. The computer company, which has hedged its entry into process control for almost three years, has formed a Control Computed Systems Div. in San Jose. The new group will be headed by Dr. Cuthbert C. Hurd, who managed IBM's preliminary entries into process control (at Standard Oil of Indiana and Standard Oil of California).

● Computer to Mechanize Drafting

San Diego—A project to mechanize the work of the draftsman with a general purpose digital computer is nearing completion at Stromberg Carlson Div. of General Dynamics. Design information will be programmed into the computer, whose magnetic tape output would run a SC-4020 high speed microfilm recorder which would then make the drawing. A normal sized drawing could be prepared in two sec. Fundamental to the system is the Automatically Programmed Tool System (APT—CtE, April '59, p. 21) developed for the Air Force. Two companies are reported ready to install the computer-draftsman as soon as it is completed.

● Automatic Switching for TV Station

Los Angeles—Television station KNXT has ordered a new computer called TASCON, Television Automatic Sequence Control, for an automatic switching system. Built by Thompson-Ramo-Wooldridge, Inc., the new computer, which can store about 2,000 events, will replace relay operated systems. Major advantage: flexibility. It is difficult to change information in the relay storage in a hurry.

100,000 Jam Interkama

European production is on the rise. Record crowds make German instrument show biggest in the world. The trend: European designs are following the American lead.

DUSSELDORF—The collossus that could be European industrial production stirred last month and appeared in a tangible form that awed even the most hardened international marketers. From all parts of Europe over 100,000 visitors stormed the second Interkama, International Congress and Exhibition of Instrumentation and Automation, to look and to buy.

Attendance at Interkama leaves no question that Europe is gearing up for mass production. The huge crowds testify to the role that instrumentation and control will play in this growth. By hosting this mammoth exhibition, West Germany served notice on the world that she plans to carve out a major share of this business for German equipment builders.

Of the total 470 exhibitors, 282 were German companies. Of those from outside Germany, 46 exhibitors were from Britain, 40 from France, 31 from the U.S., and 30 from Switzerland.

Germany's measurement and control industry is now running at a $275 million a year clip—up from the $235 million a year sales reported at the first Interkama in 1957. Leading categories: mechanical and optical instruments, $122.8 million; electrical and electronic measuring instruments, $78.75 million; and electric and electronic controls, $33.2 million.

But German makers are still suffering with delivery delays. Some makers are quoting 12-18 months delivery on standard control equipment. These long delays have given U.S. manufacturers an edge in quotations despite American companies' higher prices.

• **Trend to follow**—As a visitor toured the exhibition, one characteristic stood out: European manufacturers have designed their equipment along conventional U.S. lines. As European companies start mass production (made possible by the establishment of the mass markets of the "outer seven" and "inner six" economic blocs), they face the same production problems that have been solved by American mass producers. So European suppliers are developing equipment along the lines of that used by U.S. companies. A Foxboro representative, for example, counted 14 copies of his company's recorder at Interkama.

German activity seemed greatest in the process control field. Hartmann and Braun AG of Frankfort transistorized and repackaged its UMC electronic control system and introduced four new systems. Siemens & Halske AG, big control maker in Karlsruhe, introduced a continuous controller to make its line more competitive with U.S. equipment. Previously S&H offered only an on/off pulse modulated controller. The electrical control system built by Askania Werke AG of Berlin has been miniaturized. J. C. Eckardt AG of Stuttgart is striving for simplified design: the company has built a new crossed bellows pneumatic controller that has only a single moving part.

Solid state logic is another area winning wide German acceptance. Siemens, for example, reported that sales of solid state logic components have grown to 10 percent of the company's relay sales. To take care of an expected bulge next year when the percentage should double, Siemens has 1,700 people making the solid state units at its Munich plant. The German company AEG also had a big static switching display at the show.

But no country can explode technically in every direction at the same time. German companies displayed few new developments in machine tool control, computers, or data handling systems. Nine machine tool systems, all experimental, had showed up at a German machine tool show earlier this year, but only two systems—both built by foreign suppliers—were at Interkama. Computers and data handling systems were taking a back seat to other developments. U.S. equipment dominated the process computer field, notably TRW Computers' RW-300 and Librascope's Libratrol 500 and LGP 30.

Here are some of the highlights reported by CtE's European editor:

Process control

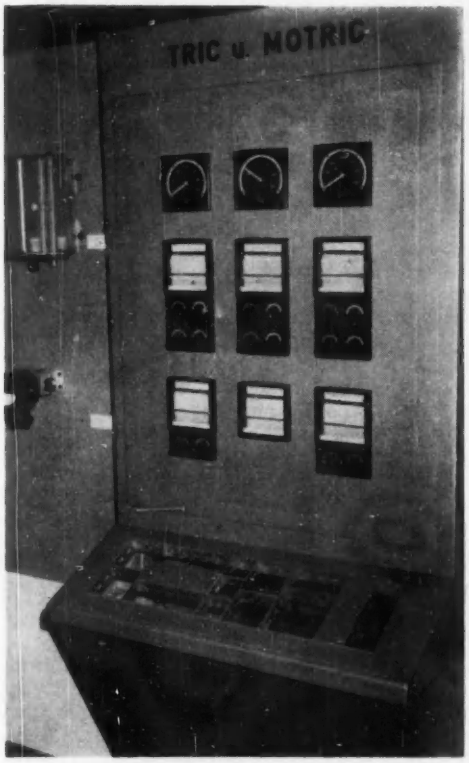
▶ Hartmann & Braun displayed four new basic electronic control systems to satisfy any combination of electropneumatic and electric operation: Contronic W, Contronic G, Motric, and Tric. With ac inputs the W system usces inductive transmitters to feed a transistorized main amplifier. Four dc inputs are available on the amplifier for mixing and introducing feedback signals. Integral and derivative terms are supplied by a separate externally mounted time delay feedback unit.

The G system is a dc version using force balance transmitters with a standardized 0 to 20-ma output. Main amplifier and output drives are the same as the W system.

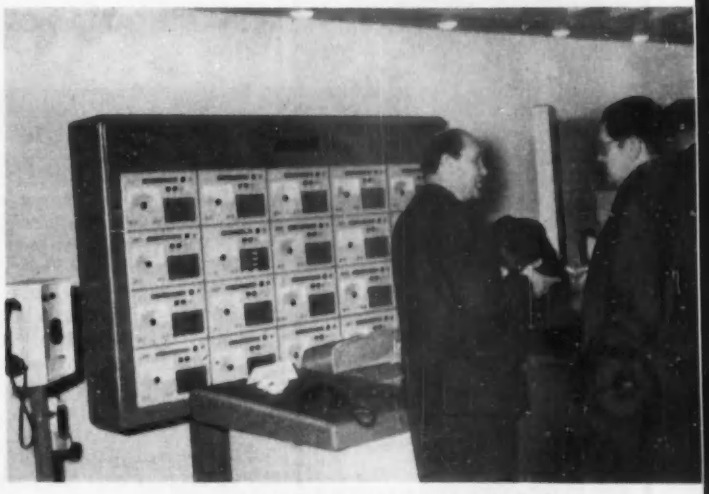
Motric, a completely electrical system, uses force balance transmitters similar to the Contronic G system. These feed an on-off PI controller to operate standard line voltage electric motor actuators. Proportional range covers 10-250 percent in 12 steps and integral time from 0.2 to 20 min.

The Tric system is similar but has dc output from the controller, available in the ranges 0-5 and 0-20 ma dc and 0-10 vdc to operate electropneumatic valves or converters. The

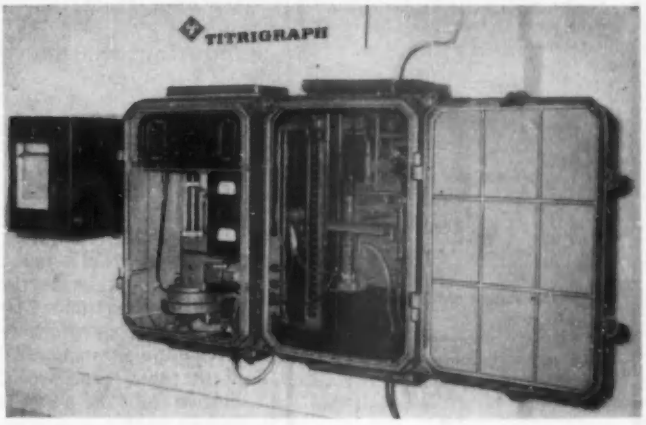
NEW AT INTERKAMA



Electronic process control unveiled by Hartman & Braun. Tric is for electro-pneumatic operation, Motric for all-electric actuators.



Production control system built by computer-maker Zusek K-G. Running time for each production machine is reported at a central point, along with scheduled production time and down time.



Automatic on-line titration unit displayed by Agfa.

system's proportional band covers 5-200 percent; integral time and derivative times are 0.5-20 min and 0-5 min.

▶Siemens & Halske's new continuous controller, Teleperm KE, is completely transistorized. It consists of three basic units: measuring unit, amplifier, and feedback system, all housed in a single panel mounting form. An electrostatic modulator with voltage sensitive capacitors converts the dc deviation signal to ac for subsequent amplification. After phase sensitive rectification, a final dc amplifier provides the power output.

A second new controller, called Ipsopneu, was also introduced by Siemens. It has electric input and pneumatic output. Ipsopneu was designed primarily for application in small plants where standardized transmission input values are not used. Interchangeable Wheatstone bridge units supply deviation signals for resistance thermometer inputs and direct current and voltage inputs. An unbalance signal from the bridge operates a moving coil actuating a pneumatic force balance system. Indicators show setpoint, deviation, controller output pressure, and valve position.

▶Askania-Werke's new controller drives an output potentiometer with an integrating drag-cup motor—an innovation to German design. The output dc signal then positions an electro-hydraulic actuator. The transistorized controller operates on a 0 to 50-ma dc input and 0 to 10-ma dc output.

▶In a new pneumatic controller built by J. C. Eckardt, four bellows are mounted on a central pillar at right angles to each other within a containing ring. A nozzle, which is coupled to a static pneumatic amplifier, moves axially around the outside of the ring. Setpoint and measured value bellows are diametrically connected within the ring so that deviation signals move the ring with respect to the nozzle. When this deviation signal has been amplified, it is the

INTERKAMA *(Cont.).....portents and prospects*

controller's pneumatic output. Feedback of the output pressure is applied through throttling nozzles to the two diametrically coupled rate and reset belows, thus further modifying the containing ring position. Price of the three-term controller: $150.

▶Staub & Co., a Swiss concern, unveiled a miniature recorder that is so small nine of them can be packed into a square foot of area. It has interchangeable measuring units for dc, ac, temperature, load, and rated values variables. Price: $120.

▶Gerate und Regler Werke, an East German Co. and one of the few exhibitors from the eastern bloc, showed a pneumatic simulator for simulating systems up to sixth order. Pneumatic controller elements are mounted above six variable pneumatic delay units. By interconnection any type of controller can be simulated. Pneumatic oscillators determine frequency response.

Industrial controls

▶Two static control systems—the Simatic by Siemens-Schuckerwerke and the Logistat by AEG—use conventional AND, NOT, and OR units. Meanwhile a Belgium company, Charleroi, introduced a single unit logic element which performs many functions with its 17 inputs and three outputs. What functions are performed are determined by cross wiring connections between rows of AND and OR terminals mounted on the base of the unit. One application of the Belgian unit is an automatic train braking control now being tested.

▶Combined digital-analog control systems are being used to reduce speed ratio scatter. Siemens-Schuckerwerke AG displayed such a control system for multimotor drives on a paper mill, claimed it cut speed ratio scatter over 14-hr test period from the 0.25-percent limit of an analog system to 0.07 percent with the combination.

▶Solid state digital control system to run the screwdown on a German rolling mill has been developed by Siemens-Schuckerwerke. The system stores 25 complete rolling programs. An unusual feature: a Hall generator with a permanent magnet is mounted on a measuring disc to provide solid state position detection to zero rpm.

▶New production control system, competitive to Siemens & Halske's Productograph (CtE, Sept. 1960, p. 140), was displayed by computer maker Zusek K-G of Bad Hersfeld, Germany, Named the Zuse Z70, it presents at a central location a three-concentric-dial display for each machine. One dial shows scheduled production time for a job, one shows actual production time, and the third reports down time. An eight-button device is mounted on the machine so that the operator can punch in the start and end of production job and five reasons for down time. Through a telephone dial the operator can report his employee badge number and the job number.

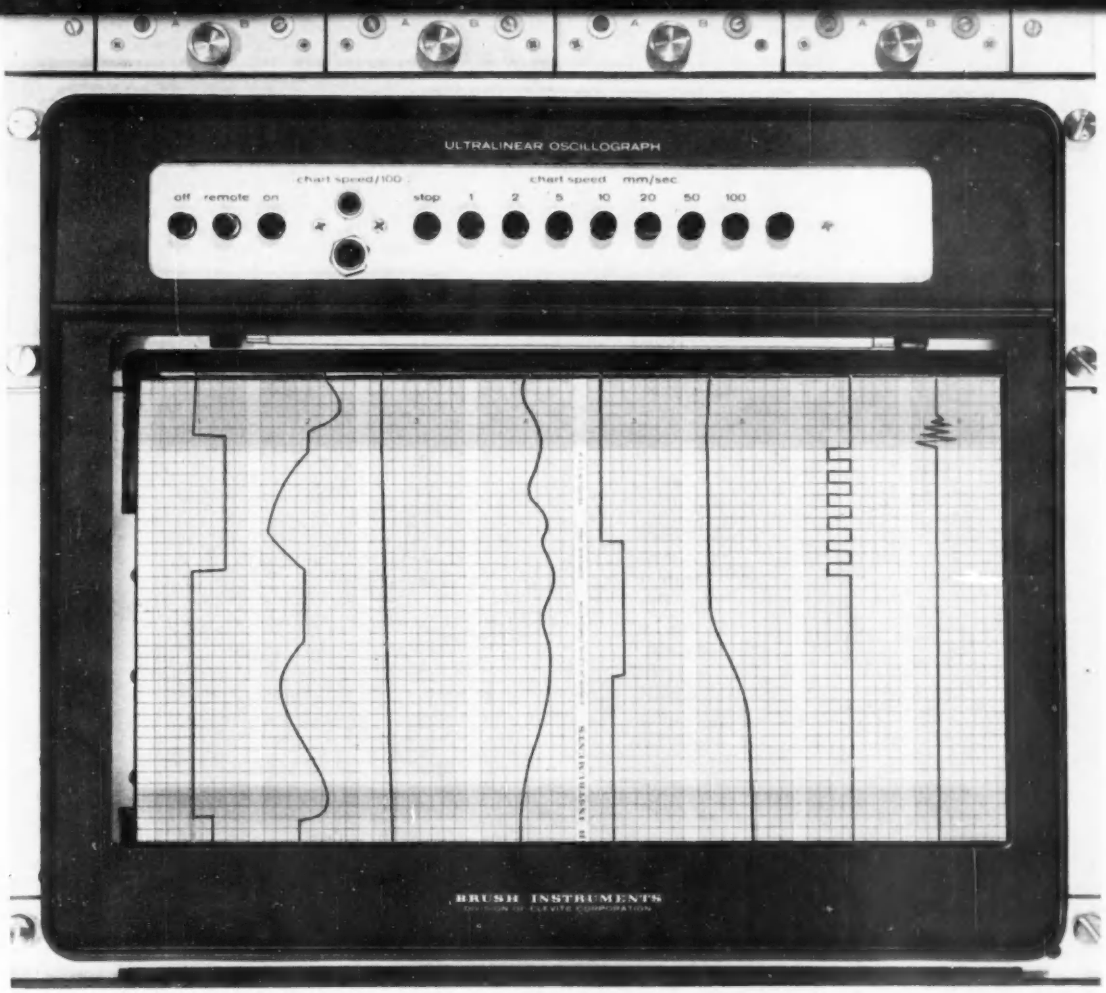
Analysis instrumentation

▶New Agfa Titrograph performs continuous on-line titrations. It has no moving parts. By measuring the position of a precision regulator controlling air pressure in the enclosed standard solution tank, the system determines the flow of standard solution required to maintain the correct pH value for the titration endpoint. Deviation of the pH value from the known end point setting is amplified to drive a dc motor which operates the pressure regulator plunger. Inductive pickoffs sense the plunger position, provide a 0 to 50-ma output for direct recorder operation, the result being proportional to unknown solution strength.

But for the most part German industry is dragging its feet in analysis instrumentation. There is little available in the areas of gas moisture monitors, refractometers, and sulfur trace monitoring equipment. European companies, on the other hand, are scoring considerable success with gas analyzers such as oxygen and infrared instruments because the European units cost about one third of competitive American equipment. Despite this, U. S. firms with facilities in Europe, such as Beckman Instruments, Perkin-Elmer, and Consolidated Electrodynamics, hold between 60 and 70 percent of the analysis instrumentation market.

How long U. S. instrument makers will maintain such margins is one of the stickiest questions raised by the giant European showing at Interkama. European firms have started to try to wrestle away some part of it.

—Derek Barlow



in multi-channel recording systems there is nothing newer

It's no wonder this recorder has been chosen for today's most advanced telemetry and computer systems. Providing the highest precision and proven reliability, Brush's newest oscillograph instantaneously displays eight 40mm channels of analog data, plus two event markers. Sharp, easy-to-read traces on rectilinear coordinates. Accurate resolution of all signals and positive interpretation of amplitude is assured with 13 electrically controlled, precise chart speeds. All functions are operated by pushbutton and may be remotely controlled if desired. Unique auto-load system locks unit in any position for greatly simplified chart changing . . . without disturbing the styli. Take advantage of industry's most advanced techniques in this space-saving vertical panel oscillograph. Get *all* the facts. Call, write or wire.

brush INSTRUMENTS
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only Brush fills all requirements for multi-channel, multi-purpose recorders

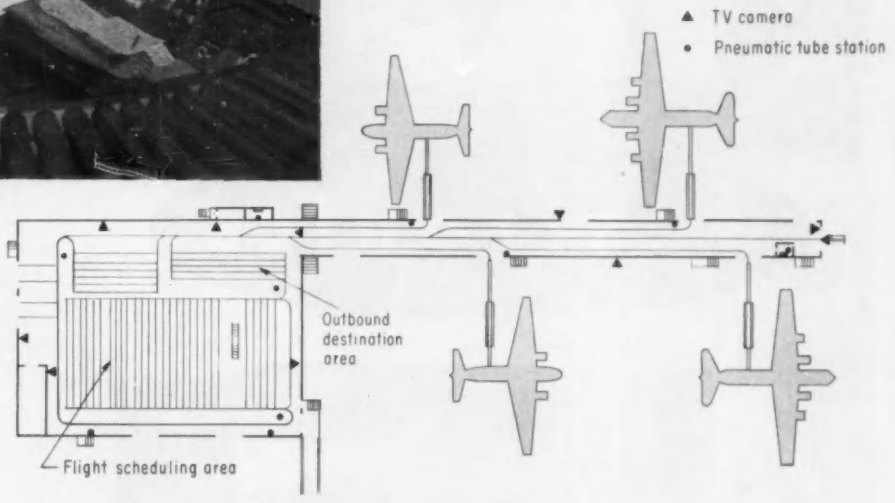
If it's precise, instantaneous data acquisition in writing . . . Brush versatile recording systems provide the answer. Whether your requirements call for this "pull-out", horizontal model for convenient annotation and reading . . . or the newest in vertical panel recorders . . . you'll find all of the known refinements in the art of recording by direct writing. Rectilinear presentation gives clear, uniform, reproducible traces for precise readout. Up to 16 chart speeds are selected by pushbutton; jam-proof transmission provides quick response. Interchangeable "plug-in" signal conditioners permit four vital functions in addition to amplification—high input impedance, zero suppression, attenuation and calibration. Event markers, internal timers, remote control and chart take-up are some of the available accessories. Check these advanced recording systems for yourself and you'll see why no one is as qualified as Brush. Write for complete details.

brush INSTRUMENTS

DIVISION OF CLEVITE CORPORATION

37TH AND PERKINS CLEVELAND 14, OHIO

Dispatcher eyes a load to read its flight number before he sends it to conveyor lane for that flight. With TV monitor he can watch any part of the 6,633 ft of conveyor lines.



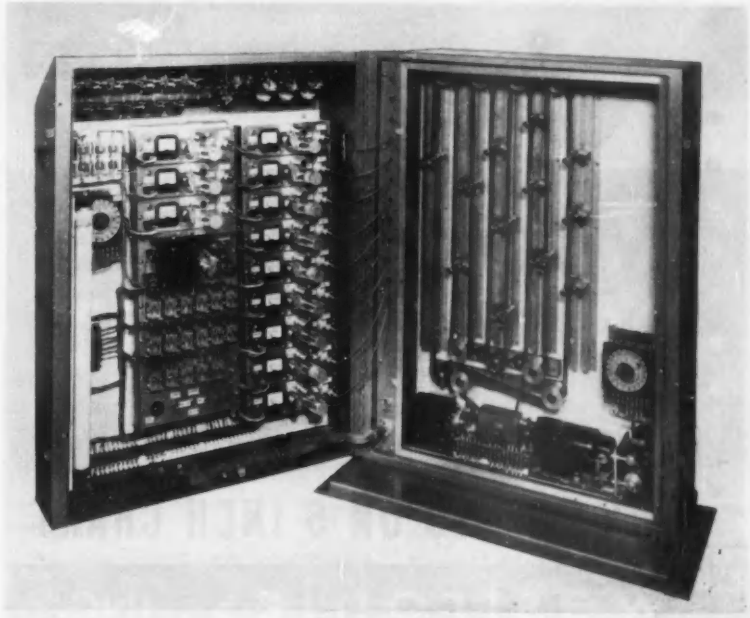
Layout of the new terminal that dispatches 7.3 million lb of cargo a month on 850 flights, bound for 86 destinations.

TV and Magnetic Tape Speed Air Force Warehousing

OKLAHOMA CITY, OKLA.— At the U. S. Air Force's new terminal at Tinker Air Force Base, supplies arrive from all over the U.S., are stored, and then are loaded on planes for transportation to Air Force bases around the world. Tinker AFB is the Air Materiel Command's biggest depot. To speed the job of getting supplies out, the Air Force has just installed a new materials handling system that is constantly watched by television and is programmed by magnetic tape.

Operations centers for the system are two identical control consoles, both made by Edon Industrial Products. One collects cargo arriving at the warehouse by truck for the proper flight; the second dispatches cargo for a particular flight based on its destination, so that material for the first stop is loaded last. Meanwhile 10 television cameras posted along the conveyor line provide eyes throughout the warehouse for the two control console operators.

Here is how the system works. Freight unloaded from a truck passes a worker who attaches a flight number



Inside the control is the closed loop of magnetic tape that serves as a memory for pushoff positions on the conveyor.

WHAT'S NEW

to the package. A copy of the invoice is dispatched by pneumatic tube to the load planner who keeps a tally on the amount of weight available for the flight and the amount allocated.

The freight then moves to the first console where an operator can assign the shipment to one of 29 conveyor lanes by pushing a button.

When the flight shipment is collected, a light flashes on the board advising the operator that no more packages should go into the lane. A light also appears on the second console, advising that operator to begin sorting the freight for loading. He sorts the load into as many as six groups and sends it out to the telescope conveyors that load the plane.

The Edon Mem-O-Trol, which does the dispatching at both consoles, uses a closed loop of magnetic tape as the memory medium for the destination information. The tape is driven through a synchro system by the conveyor being controlled. It moves at a speed proportional to the speed of the conveyor. Therefore distance along the tape can be translated into distance along the conveyor.

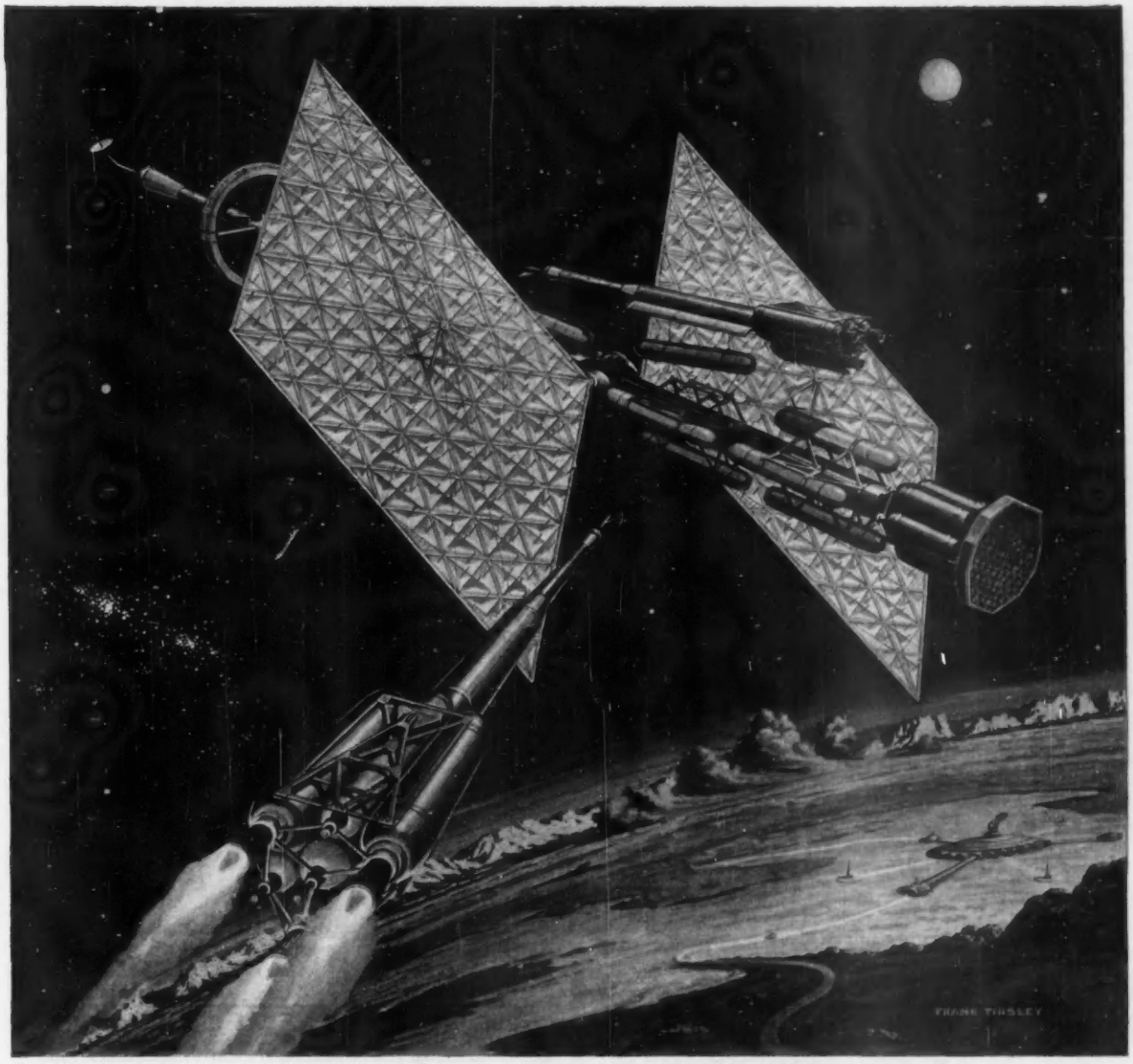
On the tape a recording channel is assigned to each possible destination. The 35-mm tape can hold up to 16 channels. In the Tinker AFB control which sorts to 29 different lanes, two tapes are used. Each channel has a recording head, at a point equivalent to the position of the control console, and a reading head, whose position depends on the destination.

When the dispatcher pushes a button to assign a lane, the poor recording head impresses a signal on the tape. It moves, proportionately to the conveyor, until the tape reaches the reading head for that channel. The second head picks up the signal which is amplified to operate a relay that controls the pusher or deflector. A magnetic eraser removes all the signals from the tape before it moves under the recording head.

A unique feature of the control is a photoelectric centering device that measures the length of a package, locates the center of it, then positions the magnetic spot on the tape based on this calculation. As a result the system can position a package in the exact center of the conveyor lane.

In addition, if the measuring equipment spots a package that is too big for the conveyor system, it will shut the line down.

—James Young
McGraw-Hill News



STEPS IN THE RACE TO OUTER SPACE

Mars Supply Fleet

When man first sets up colonies on Mars, his life will depend on a Mars Supply Fleet, shuttling from Earth at regular intervals with supplies, equipment and personnel.

The fleet will be comprised of two basic vehicle types, both shown in the illustration above. The large ships with rectangular solar reflectors will be the long-range backbone of the fleet. Assembled in orbit of prefabricated sections rocketed up from Earth, these high-capacity carriers will have a low-thrust electro-particle drive. Their operating current will come from thermionic converters, heated by the concentrated rays of the reflectors.

The Solar Ships will be loaded and unloaded, at both ends of the voyage, by work-horse Ferry Rockets (foreground) launched by booster. The ferries will be designed to carry the long yellow cargo containers within a bay just forward of their engines. In the nose of the Ferry Rocket is the passenger and operating section with a universally mounted spherical guidance compartment. This guidance unit will be fitted with directional radar, an optical telescope, and full astrogational equipment.

The Mars Supply Fleet will complete each assigned mission in one to two Earth years, depending on whether or not the Solar Ships are equipped with auxiliary boosters for extra initial speed.

ARMA, now providing all-inertial guidance systems for later models of the Air Force ATLAS ICBM, is in the vanguard of the race to outer space. At ***ARMA***, privately funded research programs in space technology are studying super-sensitive inertial devices for navigation and satellite instrumentation. For this effort, ***ARMA*** seeks scientists and engineers experienced in astronautics. ***ARMA***, Garden City, New York. A Division of American Bosch Arma Corporation.

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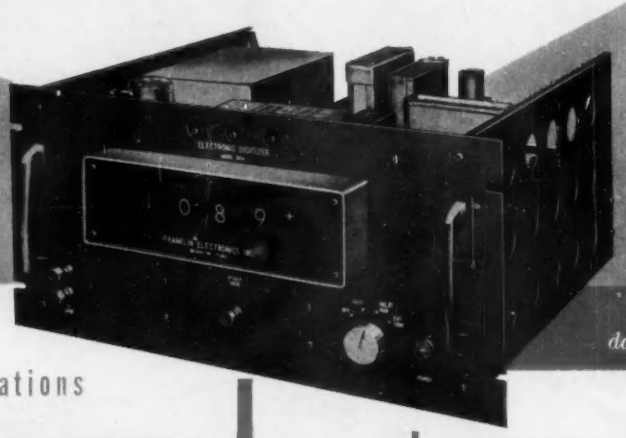
MODEL 1310N A-to-D CONVERTER/VOLTMETER

There's never any need for exasperating knob twiddling with a Franklin Model 1310N. Magic? No, just plain practical design. All operating potentials, including the line voltage, are regulated before they're put to work. What's more, there are no stepping switches, relays or other mechanical components to introduce noise or delays . . . it's all-electronic for whisper-smooth voltage conversion . . . and with a stability never before equalled. The brief specs tell more.



MODEL 1310N, ALL ELECTRONIC ANALOG-TO-DIGITAL CONVERTER/VOLTMETER..... $2090*

request data sheet 2006

brief specifications

RANGES:	000.0 to 120.0 V dc. Input sensitivity: 0.1 V per digit. Matching amplifiers are available with minimum ranges of 1 mv per digit or 100 uv per digit.
RANGE AND POLARITY SWITCHING:	Optional automatic or manual (with amplifier).
ACCURACY (ABSOLUTE):	± one count (± 0.1% of full scale) after 10-minute warmup.
STABILITY:	Absolute accuracy is maintained for at least one year without calibration.

INPUT IMPEDANCE:	100 megohms.
READOUT TIME:	Maximum of 12.2 milliseconds to 120.0 volts full scale.
SPEED:	Up to 40 readings per second.
POWER:	100—125 V, 60 cps, 200 watts.
DIMENSIONS:	19" rack panel unit, 8¾" H x 15" D.
WEIGHT:	Approximately 50 pounds.

*Prices are F.O.B. BRIDGEPORT, PENNSYLVANIA.

FRANKLIN electronics, inc.

BRIDGEPORT PENNSYLVANIA

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You count best when you count on FRANKLIN

Electronic Teacher Conditions the Reflexes

First machine ever built to exploit the psychological principle of conditioned response has a promising future: training keyboard operators.

SILVER SPRINGS, MD.—The electronic teaching machine illustrated below represents a radical innovation in equipment: it is the first device based on the psychological principle of conditioned response.

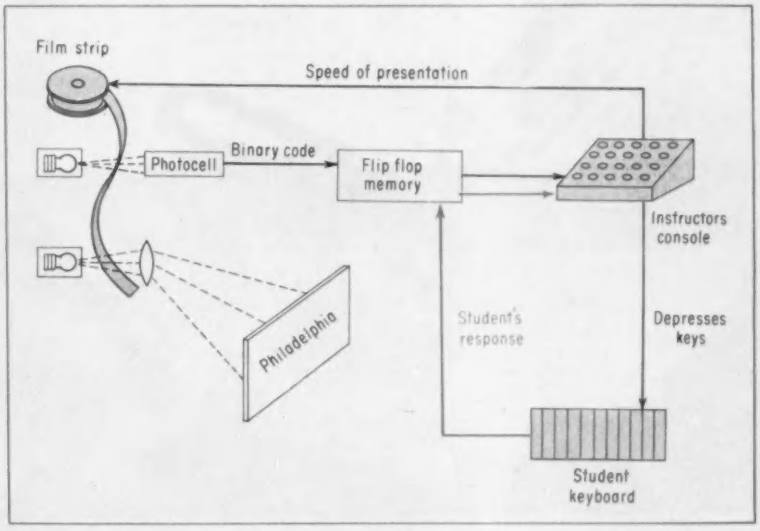
Designed to train keyboard operators (for such equipment as key punches and typewriters) the machine teaches the student through his fingers instead of by the conventional methods of paired associates (example: in touch typing instruction the letter a has to be associated in the student's mind with the far left key in the second row of the typewriter keyboard). The new teaching machine flashes a visual stimulus to the student, then moves the proper key or keys against his fingers. By reflex action the student automatically responds: the affected finger or fingers push back.

• **Providential post office**—For many years conditioned response as a method of training has been a pet project of E. F. Shelley, president of USI Robodyne, a division of U. S. Industries. Shelley and Robodyne's Chief Engineer J. Goodell tinkered with hardware but they were waiting for a solid application to prove their concept. The Post Office's new modernization program came along at just the right time.

Faced with the problem of quickly and economically training a large number of unskilled people to use new semiautomatic mail sorting machines, postal officials commissioned Robodyne to produce a special purpose trainer. The result was unveiled last month.

• **Three parts**—Robodyne calls its new training system Digiflex. It has three main parts: a student station, an instructor station, and a projector-programming unit.

From the outside the student station looks exactly like the operator's portion of a mail sorter. Its keyboard, divided into two groups of five each, has 10 keys which duplicate exactly



The Digiflex system as it was built (bottom) and in schematic form (above). Black lines indicate path of program and control signals. Red lines indicate student's responses. In the photo a male instructor adjusts the rate of presentation for a female student.

WHAT'S NEW

the movement of the sorter keys.

The instructor station is a desk-like unit with a small lighted panel. One instructor station can control up to 20 student stations. Through the lighted panel the instructor can set the rate of presentations, watch for error lights which indicate student mistakes, and program the action of the keys in four modes. He may have the correct keys push up, the incorrect keys drop away, both actions, or neither.

To program the instruction—in this case city names or post office destinations—a 35-mm film carries each representation in two forms: conventional alphanumeric and in binary dot code. The programmer-projector unit flashes the alphanumeric representation on a screen before the student. At the same time a photoelectric cell reads the binary code and transmits it to a solid state flip-flop memory.

The memory stores the information and transmits the signals associated with the proper keys for the representation on display. The signal is moved via the instructor's console because he sets the mode of operation.

The response of the student's fingers, pushing back, actuates limit switches in the student station sending signals back to the memory where they are compared with those from the film. If the student has erred, a light flashes on the instructor's console.

• **Repetition**—As a training program starts, a representation, say *Philadelphia*, is flashed before the student. At it appears on the screen, the keys associated with the code for *Philadelphia* push up, the rest drop away. *Philadelphia* is flashed repetitively several times and the operator responds. But each time the trainee sees the name he doesn't have to think; he strikes the keys automatically from habit. Thus the trainee learns by experience rather than by discussion.

Robodyne has sold seven instructor stations and 55 student stations to the Post Office Dept. The technique, says inventor Shelley, has much wider implications. With some "subtle design changes", he says, Digiflex can key punch operators or even typists.

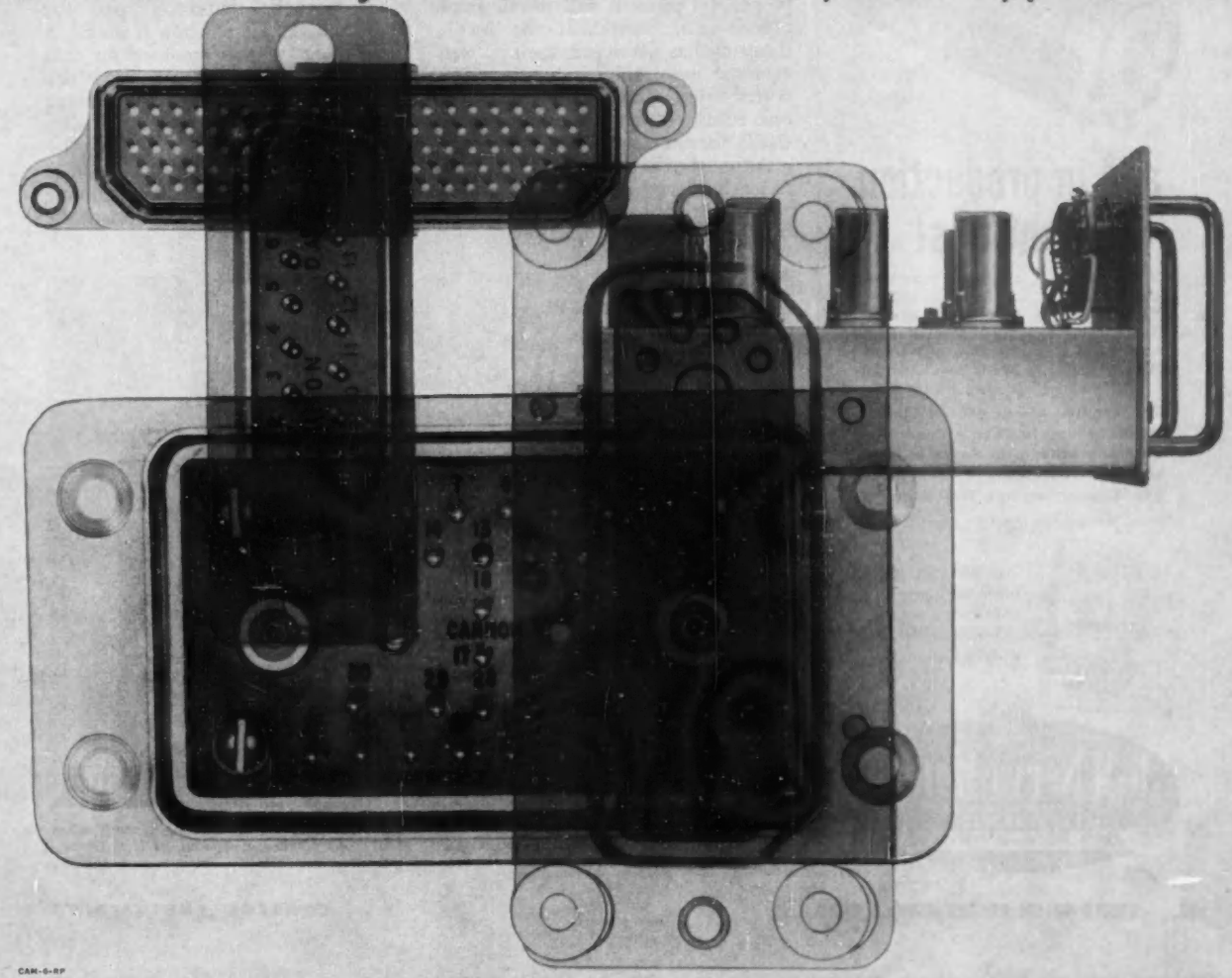
As yet nobody has any statistics to indicate how much faster operators can be trained with Digiflex. Robodyne executives feel it will cut at least 50 percent from training time. But probably one of the biggest advantages of the conditioned reflex technique is that it prevents the student from learning the wrong way and then having to relearn.

CANNON PLUGS

The assembling of highly-flexible electronic systems and subsystems into a modular package . . . for fast inspection, testing, service, and replacement of components . . . calls for standardized-type plugs throughout the system. Reliability and optimum flexibility in shell designs and types of layouts are the design criteria for the more than 18 different basic Cannon Modular and Rack/Panel Plug Series. This Series is available in standard, miniature, or subminiature sizes . . . for standard or printed circuitry. Up to 180 contacts and a varied combination of contacts for control, audio, thermocouple, co-ax, twin-ax, and pneumatic connections. Single or double-gang. With or without shells. The Rack/Panel Series ranges from the tiny "D" subminiature to the heavy-duty DPD Rack/Panel Plug. For further information on Cannon Modular and Rack/Panel Plugs write for Cannon DP Catalog, Cannon Electric Co., 3208 Humboldt St., Los Angeles 31. Please refer to **Dept. 422**, Factories in Los Angeles, Santa Ana, Salem, Toronto, London, Paris, Melbourne, Tokyo. Distributors and Representatives in the principal cities of the world.

CIRCLE 41 ON READER SERVICE CARD

Maximum Flexibility for Modular and Rack/Panel Applications



CAN-6-RP

Will Production Monitoring Spur Textiles?

Automatic production monitoring and control systems caught the fancy of visitors to the Annual Southern Textile Exposition. They may spark a renaissance in textile plants.

GREENVILLE, S. C.—Notoriously backwards in mechanization and automatic control, the 4,000-year-old textile industry may be ready to break out in a spate of modernization brought about by the installation of automatic production monitoring and control systems. Visitors to the 21st Annual Southern Textile Exposition saw several new systems designed exclusively for the textile industry, were buzzing about rumors for a "fully-automated" spinning mill to be built by Deering-Milliken near Spartanburg, S. C.

According to unofficial reports, the proposed DM mill will unveil some experimental equipment the textile company has developed itself as well as some new sophisticated gear imported from abroad. Company officials admitted that a radical new mill was in the plans stage.

Although the textile industry still seems burdened by a low profit margin—as little as 2 percent on sales compared to as high as 10 percent in other areas of manufacturing—and relatively low cost labor so that savings from a tape controlled bank of spindles, for example, are small compared to those from a tape controlled milling machine—textile men are cheered by advances that are appearing.

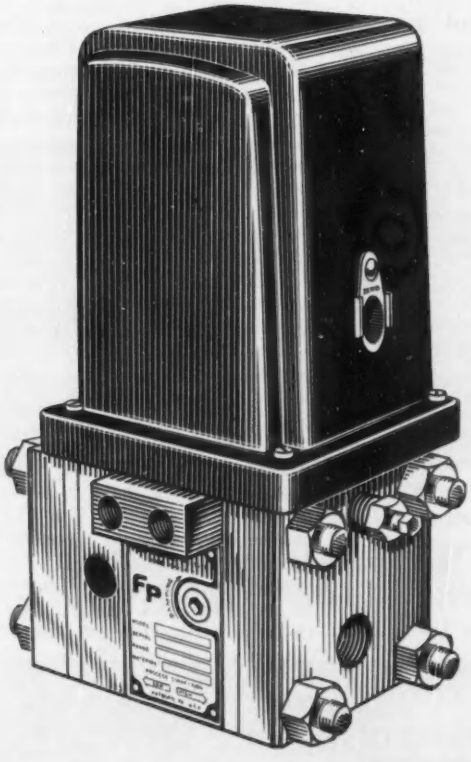
• **Fiber breaks**—Typical of the new trend is one new production monitoring system that attaches to a spinning frame of an ordinary bank of spindles to warn of fiber breaks. Developed by Adams, Inc., the system automatically detects breaks in fiber roving (as thread is drawn from a 1/30 in. diam to a 1/240 in. diam), counts the breaks, and signals an operator when a predetermined number of breaks has occurred on a machine.

Previously, an operator had to check periodically each spindle and look for breakage. With the new system, says an Adams spokesman, an operator can run twice as many machines.

A magnetic transducer spots the broken fiber. Here is how it works. A small metal clip is mounted on each spindle's "spinning ring", which guides the yarn through the twisting operations. As the ring spins, the clips also rotate at about 7,000 rpm, disturbing a low voltage magnetic field. When a fiber breaks, the spinning ring stops, and because the magnetic

Production monitoring system for spinning frame. Red light warns when more than predetermined number of fibers are broken. Detecting system is located on bottom spindles—one detection set for each spindle.

■ This DP Transmitter is as close as anyone has come to the perfect process instrument. It performs every function a differential pressure transmitter *can* perform . . . dependably and competently. Every potential of an elegant and original design has been realized in the manufactured product. For example: adjustable damping in the differential sensing system lets you measure pulsating flow without zero shift, phantom signals, diaphragm fatigue, or premature part failure. A sealed measuring chamber filled with silicone oil is positively isolated from destructive process fluids. And the entire instrument is ruggedly constructed to take a beating and remain accurate and responsive. This, then, is an instrument you can install and forget. It has yet to betray a user's confidence.



Every fact you could desire about our DP transmitter can be found within the covers of our Catalog 10B1465. But nothing can ever take the place of an actual field trial. We'll gladly arrange one for you.

Fischer & Porter Company,
820 County Line Road, Warminster, Pa.

FP
FISCHER & PORTER COMPANY
COMPLETE PROCESS INSTRUMENTATION

Sonic depth gage is mounted on this column-forming machine. It booms a sound signal across the column; and if the density is too high, the sound wave is blocked.

field is no longer disturbed, a low voltage signal is interrupted.

In the control box one circuit from each spindle is scanned several times a minute. When a predetermined number of circuits have been interrupted—by broken fibers halting the spinning rings—a red warning signal lights to alert the operator.

• **More warning systems**—Another safety control, also built by Adams and relying on the magnetic field interruption technique, prevents large diameter roving from piling up after a break. When the roving of such heavier thread breaks, a pileup can ruin a whole bank of spindles. So this system reacts to a fiber break by crimping the roving so that the upper spindle stops.

• **Ultrasonic instrumentation** — A sonic detector to control the level and density of loose woolen material was also introduced. Formerly the material was weighed in a pan in a mechanical scale. With the new system, built by Fiber Controls Corp., sound is beamed across the 60-in. width of woolen stock as it is fed into the top of a column-former. Too dense material blocks the sonic beam, stopping feeding.

• **Programmers enter**—A device familiar to process control engineers showed up at the textile show for the first time. It was the Card-O-Timer punched card program controller built by Taylor Instrument Cos. (The system's present design was introduced at the 1959 ISA show). The controller can program 20 functions of 20 steps each over 80 time periods.

With Card-O-Timer, Excelsior Mills is programming "dolly-washing", a wet process in which impurities are washed out. And it is also running a woolens-finishing operation.

—B. E. Barnes
McGraw-Hill News

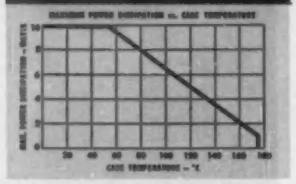
General Instrument Semiconductor

SHARPEST ZENERS AVAILABLE!

NOW... GI OFFERS YOU A COMPLETE LINE OF QUALITY ZENER DIODES

NEW 10-WATT ZENERS...

- *Extremely low Dynamic Impedance*
- *Superior Case Design*
- *Up to 175° C Operation*
- *Diffused Junction Type*
- *100% Scope Tested*



Outstanding Quality—New line of superior quality 10-watt zener diodes provides dependable uniformity of electrical characteristics... *completes* the family of General Instrument zeners. Unique case design, which employs thermal matching of silicon and package, enables units to withstand rapid temperature cycling and thermal shock. Low junction operating temperature means high reliability and long life. Conservatively rated diodes show extreme stability under life tests at maximum parameters.

New Diodes Available for Immediate Delivery in Types 1N1808; 1N2044 through 1N2049; and 1N1351 through 1N1362. Voltage ranges from 7.5 to 30 volts (higher upon request).

REPRESENTATIVE GROUP OF SUPERIOR ZENERS FOR YOUR MOST EXACTING CIRCUIT REQUIREMENTS... 10 WATTS TO ¼ WATT

(Standard types supplied ± 10% of stated value; ± 5% tolerances available except as indicated.)

New 10-Watt Zeners				3.5-Watt Stud Mount†				1-Watt Axial Lead†				¼-Watt Axial Lead			
Type	Zener Voltage (v)	Test Cur. @ 55° C (ma)	Max. Dyn Imp. (ohms)	Type	Zener Voltage (v)	Test Cur. @ 25° C ma	Max. Dyn Imp. ohms	Type	Zener Voltage v	Test Cur. @ 25° C ma	Max. Dyn Imp. ohms	Type	Zener Voltage v	Test Cur. @ 25° C ma	Max. Dyn Imp. ohms
1N1808	9.1	500	1	1N1588	3.6-4.3	150	2.6	1N1518	3.6-4.3	50	9	1N708	5.6	25	3.6
1N1351	10	500	2	1N1589	4.3-5.1	125	2.3	1N1519	4.3-5.1	40	8.5	1N714	10	12	8
1N1352	11	500	2	1N1590	5.1-6.2	110	1.4	1N1520	5.1-6.2	35	5.5	1N718	15	12	13
1N1353	12	500	2	1N1591	6.2-7.5	100	.58	1N1521	6.2-7.5	30	1.6	1N721	20	4	20
1N1355	15	500	2	1N1592	7.5-9.1	80	.5	1N1522	7.5-9.1	25	1.1	1N723	24	4	28
1N1357	18	150	3	1N1593	9.1-11	70	.7	1N1523	9.1-11	20	1.5	1N731	51	4	115
1N1358	20	150	3	1N1594	11-13	50	1.4	1N1524	11-13	15	2.4	1N735*	75	2	240
1N1359	22	150	3	1N1595	13-16	40	3.4	1N1525	13-16	13	5.4	1N738*	100	1	400
1N1360	24	150	3	1N1596	16-20	35	6	1N1526	16-20	10	11	1N742*	150	1	860
1N1361	27	150	3	1N1597	20-24	30	9	1N1527	20-24	9	18	1N744*	180	1	1200
1N1362	30	150	4	1N1598	24-30	25	13	1N1528	24-30	7	28	1N745*	200	1	1400

*Supplied with ± 10% tolerance only.
†Intermediate values supplied with ± 5% tolerances on order.

CONTACT GENERAL INSTRUMENT for full technical information on the complete line of zener diodes, and for applications assistance on all your semiconductor needs.

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WHAT'S NEW

Union Explodes over Automatic Train

ROCHESTER, N. Y.—"An automatic railroad is like a toy train. It is efficient if you get the proper teenager to run it. . . . It's a Coney Island Gadget."

That was just part of the vituperative outburst attributed to Michael J. Quill, demagogic head of the Transport Workers Union, when he learned that the New York City Transit Authority has tried out an automatic subway train system. Quill threatened a strike if the Authority goes through with a plan to put the train on the famous Times Square-Grand Central shuttle run.

The automatic electronic train control system that evoked Quill's wrath was built by General Railway Signal Co. In addition to the New York test, the system has also been successfully tested on a Canadian railway, which automated a regular freight locomotive to haul a full load of cars automatically. And at a mining operation in Labrador, the same system is in regular service hauling mined ore to a processing plant, a distance of about a mile. Boston's Metropolitan Transit Authority is also examining the system.

GRS's system needs no train crew. In the New York test, for example, the system ran all movements of the train automatically, opening and closing doors, changing destination signs, and switching on headlights as a train moved over a Brooklyn branch of the subway (from the New Utrecht stop to the 18th Ave. station).

• **Inductive control**—Control signals were initiated by a programmer and automatic dispatcher, located in a trackside instrument box. Commands in the form of coded pulses were applied inductively to the rails of the track and to wire loops between the rails (in other installations, the commands have been transmitted as carrier pulses over wire pairs). Receivers on the train picked up the signals inductively so that there was no physical contact between the train and wayside control equipment. (New York subways are powered by a third rail so there is physical contact for power.)

As a safety feature, the trains were interlocked with safety devices to protect against collision with other trains, incorrectly thrown track switches, or broken rails. Even the door controls were interlocked to prevent starting the train until the doors were completely closed.

As a further indication of the system's capabilities, in the Canadian Railway test, tuned wayside coils made the diesel locomotive recognize grades, curves, and "slow order" work areas so that speed could be regulated to match the roadbed conditions.

—Desmond Stone
McGraw-Hill News

Start Speed Mail Test

WASHINGTON—Post Office Department has started tests of facsimile mail—almost instant transmission of letter mail. In the test, government correspondence is being flashed between Washington, D. C., Battle Creek, Mich., and Chicago, Ill.

Prime contractor for the experimental system is International Telephone and Telegraph Co. Major subcontractors: Stromberg Carlson for the electronic facsimile equipment, and Pitney-Bowes for physical handling equipment that automatically opens letters and seals the facsimile message.

The feature that makes this system unique from other facsimile arrangements is the unusual Stromberg Carlson scanner. Previously facsimile systems have been analog; this one is digital.

Scanning makes use of video extraction techniques. Light output of a cathode ray tube is reflected along a scanning mirror to a second semi-transparent mirror. Sixty percent of the light proceeds to scan the message, forty percent bounces against a reference target.

A photomultiplier tube picks up the message signal and produces a pulse—a yes/no pulse corresponding to black or white—which is microwaved or carried by coaxial cable to a printer. A second photocell picks up the signal from the reference target and carries it back to the grid of the cathode tube to correct the intensity of light for each scan.

The most stringent requirement of the system is that the light level be uniform. If the closed-loop feedback system cannot correct the light intensity to obtain uniform scan, it shuts the equipment off.

A square wave is the output of the message signal. To produce this, S-C resets clipping level for each pulse instead of clipping the signal on an arbitrary level. Each pulse is captured in a delay line and then a sample of the pulse is analyzed and the gain automatically set before pulse arrives at the amplifier where it is clipped. This operation cuts out most of the noise; additional clipping converts the signal into a square wave of variable width.

Telechrome Builds New Image Around Data Communication

Starting in the television industry, this company now aims its major interest at data communications and handling equipment that ranges from a special purpose control computer to errorless data transmismission gear.

AMITYVILLE, N. Y.— Within the next 60 days a small but growing Long Island company will introduce a radical new device for data transmission: two small black boxes that will guarantee that the transmission path will not introduce errors into a data system no matter how long the path or how fast the rate of transmission. Almost certain to cause a stir in the field of information systems, where data communication is a mushrooming interest, the equipment is symbolic of the new direction that its builder, Telechrome Manufacturing Corp., has taken. In the past three years Telechrome has switched its concentration from TV broadcasting instruments to control gear.

When Telechrome was founded in 1950 by its current president, J. R. Popkin-Clurman, the television industry was expecting a boom in color TV comparable to the explosive reception that greeted black and white TV. The company designed and marketed a line of high quality test instruments and broadcast equipment for color transmitters and grew as color TV expanded. But the boom never developed. In fact by 1957, the color bubble had burst and Telechrome found itself in a static market.

• **Blueprint for growth**—Studying what to do next in an agonizing reappraisal, Telechrome executives recognized that a TV picture had a lot in common with the growing field of data handling. If a TV picture is data, they reasoned, wouldn't many of the pulse and signal techniques which Telechrome had developed for the broadcasting industry be applicable to data reduction? Convinced that the company's know-how could be applied in other industrial areas, the executives drew up a new master plan for Telechrome.

They charted three big areas for the company's future growth: 1) communication of information, 2) instrumentation for automated process control, and 3) control equipment. And they made one other big decision: the company would start its new activity with the steel industry as an initial customer target.

As planned by Telechrome the program would need some outside technical help and would cost a lot of money, more cash than the company could lay its hands on. Unable to finance the buildup of its own capabilities in these three new areas, Telechrome started to acquire the needed know-how by buying companies in exchange for Telechrome stock.

First it acquired Encapson Products whose specialty was data handling on wire links. Later the company bought the Hammerlund Mfg. Co. which built communications equipment, centralized operational controls for utility applications, and a line of precision variable air capacitors. And just recently Telechrome acquired an option to buy Universal Transistor which makes power supplies and nuclear radiation instruments.

To meet the challenge of expansion into three new fields, Telechrome organized itself into four major divisions:

▶ Electronics Div.—To build video broadcast and test equipment, to develop radio telemetry gear, and to design special devices such as a low cost video magnetic tape recorder.

▶ Hammerlund Manufacturing Div.—To build electronic components such as relays, switches, and special connectors; to design and make communication equipment for the industrial, military, and marine market.

▶ Hammerlund Automation Div.—To build control equipment; to design and install centralized operating control, its supervisory control system; and to perform system design for any of the company's divisions, sometimes coordinating contributions from more than one of the company's groups.

▶ Universal Transistor—To build power supplies and to design and manufacture nuclear radiation detection instrumentation.

• **System byproducts**—In the development of the company's first large

TI YOUR ONE-STOP SOURCE . . . FOR COMPUTER COMPONENTS!

From economy devices to industry's fastest switchers . . . all of the high-performance computer components you need are immediately available from Texas Instruments! Only TI offers you such a wide line of specifically designed computer components ***plus*** the ability to supply high-performance devices in mass production quantities . . . ***when you need them.***

TEXAS INSTRUMENTS DEVICES SPECIFICALLY DESIGNED FOR COMPUTER APPLICATIONS

	PERIPHERAL EQUIPMENT	LOGIC	MEMORY	POWER SUPPLY
GERMANIUM TRANSISTORS	2N1038 Series, 2N1046 Series — Driver 2N1302 Series — Logic and Medium Power Driver 2N250 Series, 2N511 Series — Electromechanical Driver	2N797 — Very High Speed 2N705, 2N710, 2N711, 2N1385 — High Speed N100, N101 — Medium Speed 2N1302 Series	2N1046 Series — Driver	2N1038 Series, 2N1042 Series — Medium 2N250 Series, 2N456 Series, 2N1038 Series — High 2N1046 Series — Power
SILICON TRANSISTORS	2N332 Series, 2N497 Series, 2N734 Series, 2N738 Series, 2N1564 Series, 2N1572 Series, 2N1586 Series — Logic and Medium Power Driver 2N389 Series, 2N1714 Series, 2N1717 Series, 2N1722 Series — Electromechanical Driver	TI 450, TI 451 — High-Speed Transistors 2N706A Series, 2N753 Series, 2N1252 Series — High Speed 2N726 — PNP High Speed 2N696 Series, 2N702 Series — Medium Speed J-460 Series, 2N337 Series — Low Speed	2N696 Series, 2N1252 Series, 2N1508 Series — Driver	2N337 Series —A, 2N342B Series—D, 2N389 Series —P, 2N497 Series —D, 2N726 —A, 2N734 Series —A, 2N738 Series —A, 2N1047 Series —P, 2N1564 Series —A, 2N1572 Series —A, 2N1714 Series —P, 2N1718 Series —P, 2N1722 —P A—Amplifier, P—Power, D—Driver or Medium Power
SOLID CIRCUIT* Semiconductor Networks		Type 502 bistable multivibrator and custom designs for logic circuits	Type 502 Set-reset Flip-Flop	
SILICON DIODES	1N2175 (Photo), LS-222 (Photovoltaic), LS-223 (Photovoltaic) — Readout Devices	C 01 — Low Cost 1N650, 1N651, 1N652, 1N653 — Gallium Arsenide Tunnel Diodes 1N914 Series — High Speed	C 01 — Low Cost 1N650, 1N651, 1N652, 1N653 — Gallium Arsenide Tunnel Diodes 1N914 Series — High Speed	1N746 Series, 1N1816 Series — Reference Power Regulators
SILICON RECTIFIERS	TI-010, TI-025, TI-050 — Controlled Rectifiers			1N253 Series, 1N538 Series, 1N1124 Series, 1N1614 Series — General Purpose Rectifiers 2N1595 to 2N1604 — Controlled Rectifiers
CAPACITORS	***fan*** **TI-cap*** Solid tantalum electrolytic capacitors—type SCM—203 standard ratings—6v to 35v—1 μf to 330 μf			
RESISTORS	CG ⅛ Hard Glass Hermetic—Precision Film—Standard Resistance Values from 24.9 ohms to 18.2 K CG ¼ Hard Glass Hermetic—Precision Film—Standard Resistance Values from 24.9 ohms to 82.5 K ⅛ watt to 2 watt—MIL-Line—Precision Film—Standard Resistance Values from 10 ohms to 50 meg Ω ⅛ watt to 2 watt—Molded—Precision Film—Standard Resistance Values from 10 ohms to 45 meg Ω			

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CIRCLE 49 ON READER SERVICE CARD

WHAT'S NEW

scale industrial control system—the length-measuring, weighing, and stenciling system for a steel tubing plant —Telechrome followed an interesting approach that has put it into the control components business. Recognizing that the total world market for such a system added up to only 100–175 installations, the company designed all the equipment in a modularized manner so that different blocks could be plugged together for different applications.

For example, one of the building blocks is a solid state, special purpose digital computer. In the steel mill application it received measurements of length and weight, continually computed weight per foot, compared the result to present high and low limits, and shut down the process if the tubing exceeded either limit. Now Telechrome has proposed a modification of the design to the Federal Aviation Agency and the U.S. Navy as a special purpose navigation computer for aircraft.

Another component that modularization turned into a separate product is the analog to digital converter for that initial steel system. Telechrome has packaged the electromechanical device and is marketing it as Mem-o-tizer, a digitizer with a memory.

• **Steady growth**—Since 1956 Telechrome sales have grown from $504,513 to $8 million estimated for next year. Employment has jumped from 75 people in 1956 to 619 in 1960.

Telechrome is counting on its soon-to-be-announced errorless transmission equipment for some of its biggest future growth. Executive vice-president S. Dubin says the company has already sold two installations, one military and one civilian. Its market, he adds: wherever sure accuracy of data transmission is a necessity.

The Telechrome errorless transmission equipment can be used with any of the commercially available data transmission systems (such at IBM's Teleprocessing, Collins Kineplex, etc.). It costs about $5,000 per black box (two are required) and would replace the parity or validity checking equipment used by some data systems. The first system for a military customer will be shipped this month.

GE Maintains Computer Pace; Adds Peripheral Equipment

Following up its recent announcement to set up a nationwide chain of data processing centers (CtE, Nov. '60, p. 199), General Electric Co.'s

(Continued on page 172)

WHY THIS IS A BETTER *LATCHING* RELAY

Better? Yes, in several ways. Bifurcated Contacts, for example, give improved reliability, especially in dry circuits. Contacts will not open during vibrations of 30Gs, 55 to 2500 cps. A special method of sealing cover to base eliminates flux contamination of the contacts. And there are more. Here is Potter & Brumfield's newest member of a distinguished family of micro-miniature relays: the FL Series.

Expressly designed for printed circuit applications, this DPDT, 3 amperes (@ 30V DC) latching relay lies parallel to the mounting surface. Its height, when mounted, is only .485", thus circuit boards may be stacked closer. Mounting can usually be accomplished without studs or brackets, simplifying installation.

The FL will remain firmly latched in either armature position without applied power, a significant advantage where power is limited and long relay "on" times are required. This relay may be operated by:

1. Pulsing each coil alternately (observing coil polarity), or
2. Connecting the coils in series and operating from a reversing (polarized) source.

Write for complete information or call your nearest P&B representative.

FL SERIES SPECIFICATIONS

Shock: 100 Gs for 11 milliseconds. No contact openings.

Vibration: .195", no contact openings. 10 to 55 cps. 30 Gs from 55 to 2500 cps.

Pull-In: 150 milliwatts maximum (standard) at 25° C. 80 milliwatts maximum (special) at 25° C.

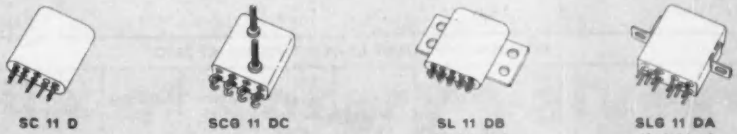
Operate Time: 3 milliseconds maximum at nominal voltage at 25° C.

Transfer Time: 0.5 millisecond maximum at nominal voltage at 25° C.

Temperature Range: −65° C to +125° C.

Terminals: Plug-in pins.

Dimensions: L. 1.100" Max.—W. .925" Max H. .485" Max. Hermetically sealed only.



SC 11 D — SCG 11 DC — SL 11 DB (Latching) — SLG 11 DA (Latching)

Other P&B micro-miniature relays include conventional and latching models in crystal cases with a wide range of terminals and mountings. All are made in a near-surgically clean production area under the exacting requirements of our Intensified Control and Reliability program.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

YOUR BEST SINGLE SOURCE FOR ALL MICRO-MINIATURE RELAYS

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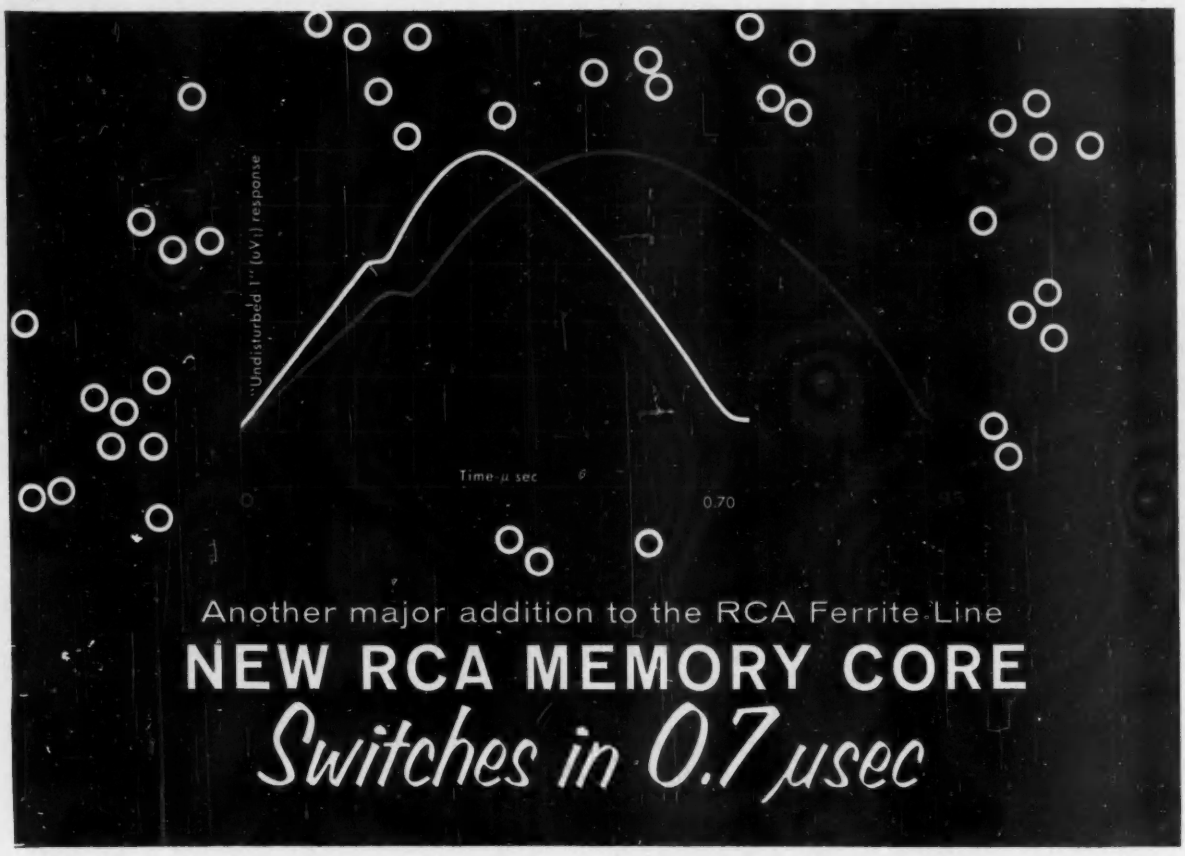

Another major addition to the RCA Ferrite Line

NEW RCA MEMORY CORE

Switches in 0.7 μsec

RCA Ferrite line now offers a choice of memory cores with faster switching times or reduced power requirements

RCA's new memory core 227M1 (XF-4138) with 0.7 μsec switching time, now opens up a wide choice of design possibilities for military and commercial computers. With the announcement of this new core, RCA now offers:

- 227M1 (XF-4138) for fast switching
- 226M1 (XF-4028) for *reduced* power requirements with *increased* operating margins
- 224M1 (XF-3018H) for standard coincident-current memory applications

See chart for comparative operating characteristics. These cores are part of RCA's comprehensive line of ferrite cores, transfluxors, and other magnetic memory and switching devices.

Systems Engineering Service

Your local RCA Field Representative is prepared to furnish a completely coordinated service, including transistor, ferrite, and memory-systems application assistance. Call him today. For technical literature on RCA Ferrite cores and memory devices, write RCA Commercial Engineering, Section F-19-NN-3, Somerville, N. J.

NOMINAL OPERATING CHARACTERISTICS AT 25°C

Type	New Feature	Size	Full Driving Current (Im) (ma)	Partial-Write Current (Ipw) (ma)	Pulse Rise Time (t_r) (μ sec)	Switching Time (t_s) (μ sec)	Response "Undisturbed 1" (uV_1) (mv)	Response "Disturbed 0" (dV_0) (mv)
226MI (XF-4028)	Lower Drive	.050"x.030"x.015"	400	200	0.2	0.95	85	10
224MI (XF-3018H)	Present Standard	.050"x.030"x.015"	500	250	0.2	0.95	75	8.5
227MI (XF-4138)	Faster Switching	.050"x.030"x.015"	500	250	0.2	0.70	105	13

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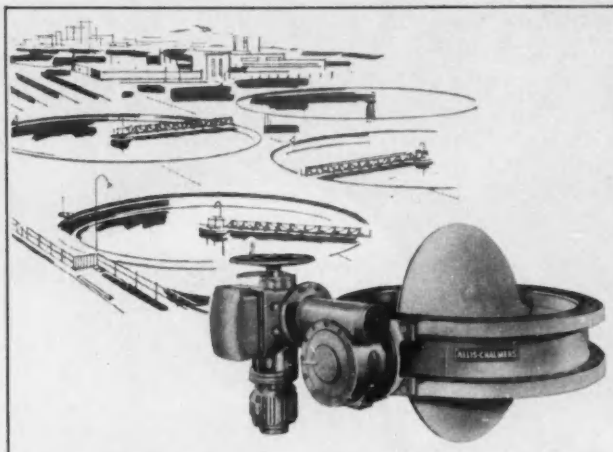
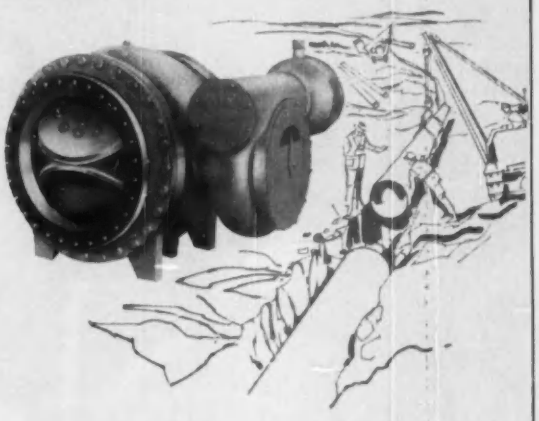
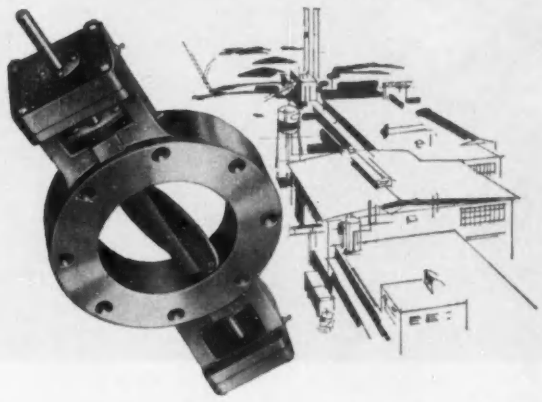
ALLIS-CHALMERS



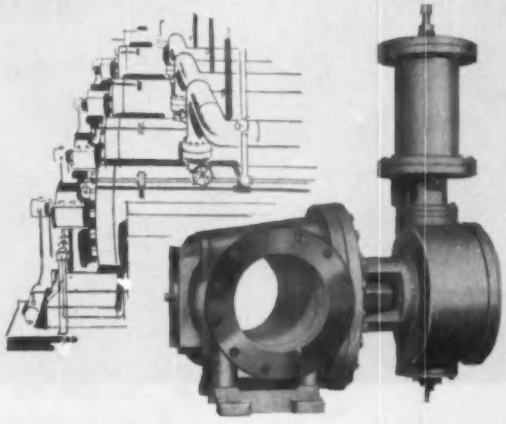
BUTTERFLY VALVES — For liquids or gases — uniform control in all positions, fast positive regulation and closure, minimum pressure drop. Compact and lightweight. Sizes from 1 in.



BALL VALVES — Easy manual shutoff under adverse conditions, and up to 150 psi. Slight wedging action gives unusually drop-tight closure. Sizes: 12 to 48 in.



WAFER VALVES — A new design of butterfly valves with space-saving flexibility, suited to most any type of operation. Sizes from 3 to 36 in., including high-pressure types.



ROTOVALVE — A cone valve suited to virtually any type of operation or location. Offers the least pressure loss, greatest initial shutoff, controlled closing time, positive seating.

Now: for power plants, sewage and water works —

a full line of rotary valves

Serving you even better through a broader line—Allis-Chalmers offers the finest in butterfly, ball and cone valves for industrial applications, power plants, sewage and water works. Also available are complete valving systems in standardized "packages" that provide *remote, telemetered control of valve operation.* These additions further round out Allis-Chalmers line that includes Angle, Needle, Relief valves, sleeve-type valves and accumulator systems. *For details, contact your Allis-Chalmers valve representative or write* **Allis-Chalmers,** *Milwaukee 1, Wisconsin.* Rotovalve is an Allis-Chalmers trademark.

A-1381

1 MODEL 28 AUTOMATIC SEND-RECEIVE SET—facilities for sending and receiving messages plus tape preparation and reading, receiving in tape, integrating tape and manual keyboarding. Incorporates major components of Model 28 line in single, compact console—a "complete station."

2 MODEL 28 SEND-RECEIVE PAGE PRINTER—for sending messages by direct keyboard, receiving incoming traffic, providing print-out facilities. Sprocket feed, horizontal tabulator and form positioning arrangements available. Both this unit and the automatic send-receive set are equipped with the "Stunt Box," a built-in control and switching device.

3 MODEL 28 TAPE READER—advanced reader-distributor design permits (1) reading of punched tape for serial transmission; (2) reading of punched tape for simultaneous output on parallel-wire basis; (3) translating of electrical impulses from an external parallel-wire source for serial transmission. Available for 5 or 6-level code.

4 MODEL 28 TAPE PUNCH—receives incoming electrical signals, punches a 5-level tape and prints-out data on the tape. Used for message relaying, combining data from several sources on a single tape, or providing punched tape as a by-product of send-receive operations for input to business machines.

Teletype Model 28 Line...

standard units that offer flexibility, economy and reliability for message and data communications systems

The Teletype Model 28 line offers facilities to meet a wide variety of requirements in message and data communications equipment. It is an integrated line, designed on the modular principle, permitting flexibility in selection and interchange of components.

Speed is 10 characters per second for page units and typing tape punches—up to 20 characters per second for tape readers and non-typing tape punches. Page printers and tape punches can be adapted for parallel-wire input.

Exclusive with Teletype Model 28 page printers and automatic send-receive sets is the versatile "Stunt Box," a built-in mechanical memory device that is automatically activated by keyboard or line signals. The Stunt Box is used for internal control of "extra" features in the printer and external control of operations that can be activated electrically. It provides a simple, economical approach to station selection and many remote control problems.

The Teletype Model 28 line is specifically designed for continuous operation and very low maintenance. All-steel clutches and simple harmonic-design elements insure reliability and greatly reduce servicing needs. For example, the lubrication interval when operating at 10 characters per second is 6 months or 1,500 hours' operation, whichever occurs first.

Teletype Corporation manufactures this equipment for the Bell System and others who require the utmost reliability from their data communications facilities. Can be used with Data-Phone and other communications services.

More Information. Write for descriptive literature folder on Teletype Model 28 line to Dept. 26M, 5555 Touhy Avenue, Skokie, Illinois.

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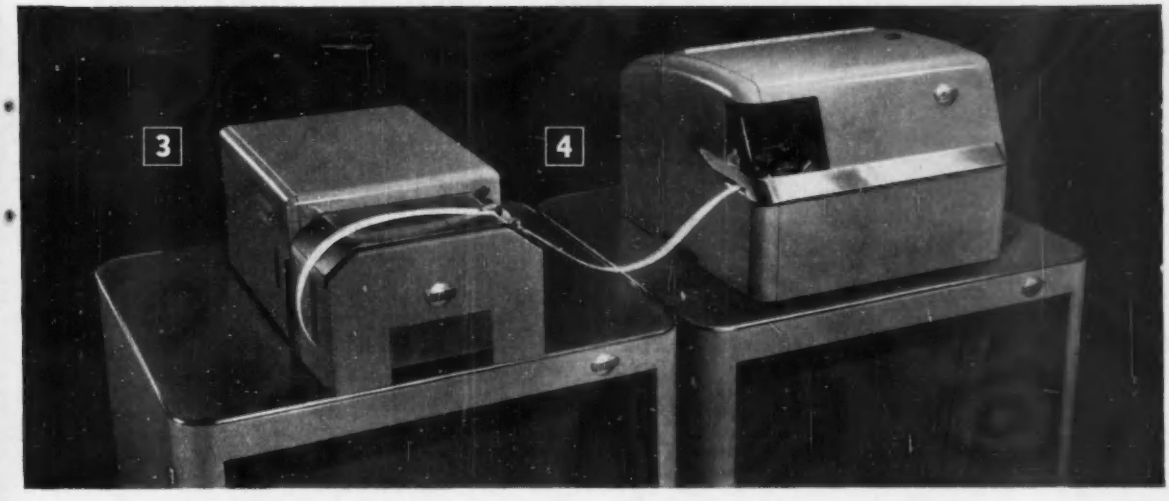

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You Fill Out The Tag...

You can choose your own performance features when you order a Fenwal 536 Temperature Controller. And get them in a *compact, low-cost, transistorized stock instrument!*

Basic member of Fenwal's new "500" family, the "536" *always* provides precise control action. You merely select from the following features to meet your specific needs: 1. Proportioning or On-Off Control. 2. Five standard temperature ranges from −50 to +600°F (Special ranges, expanded scales, and centigrade scales available). 3. Dial for set-point adjustment externally or internally mounted. 4. Separate potentiometer with graduated dial and knob for remote adjustment. 5. Cartridge, hex head, flange or coupling head probe for thermistor sensor. All configurations have a rating of 10A-115VAC or 5A-230VAC. *You buy exactly what you need!*

Of course, for the user who needs most of these features, it may make more sense to order a Fenwal 561 Indicating Controller . . . with indication as a *plus*. And for multi-point indication, as many as ten 536's can be plugged in to a 580 indicator. Get catalog on the complete "500" Line. Write FENWAL INCORPORATED, 2911 Pleasant Street, Ashland, Massachusetts.

Another example of how

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

Tung-Sol Silicon Power Rectifiers

Diffused Junction and Alloy Junction

New freedom for designers

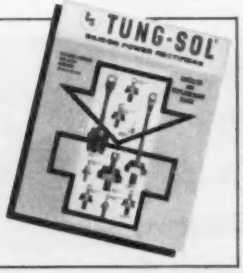
Designers who seek more freedom to use economical components while obtaining maximum equipment reliability should become thoroughly familiar with the Tung-Sol line of silicon rectifiers.

All Tung-Sol rectifiers are designed and manufactured to the same unexcelled standards of quality. At the very minimum, the entire line meets the toughest requirements laid down by military specifications. And you can be sure that wherever more rigid commercial specifications exist, Tung-Sol rectifiers will equal or exceed these higher performance and reliability demands. All in all, Tung-Sol rectifiers afford the widest design flexibility.

This select Tung-Sol line is available in production quantities immediately from stock and at conservative prices. Tung-Sol Electric Inc., Newark 4, N.J.

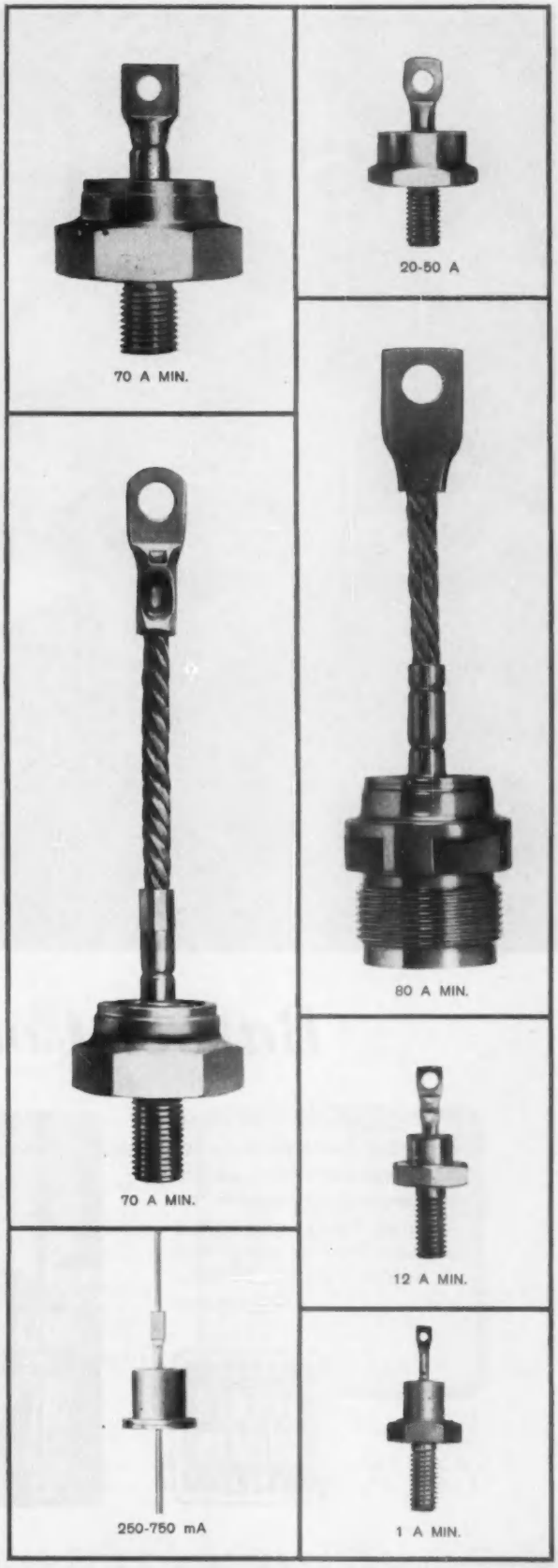
New Interchangeability chart available

Write for Tung-Sol silicon power rectifier interchangeability chart and catalog today. Forty-four Tung-Sol types replace more than 300 competitive types.



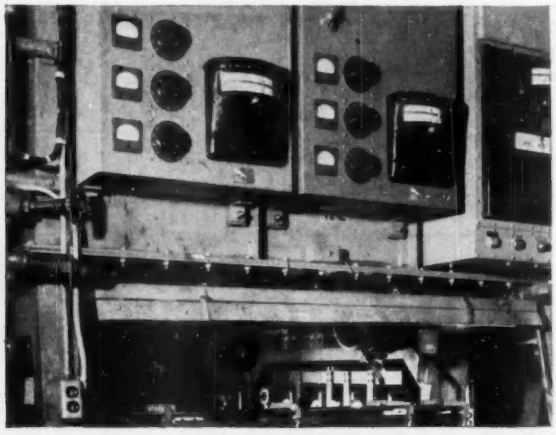
TUNG-SOL®

Technical assistance is available through the following sales offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Texas; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Newark, N. J.; Philadelphia, Pa.; Seattle, Wash. CANADA: Toronto, Ont.



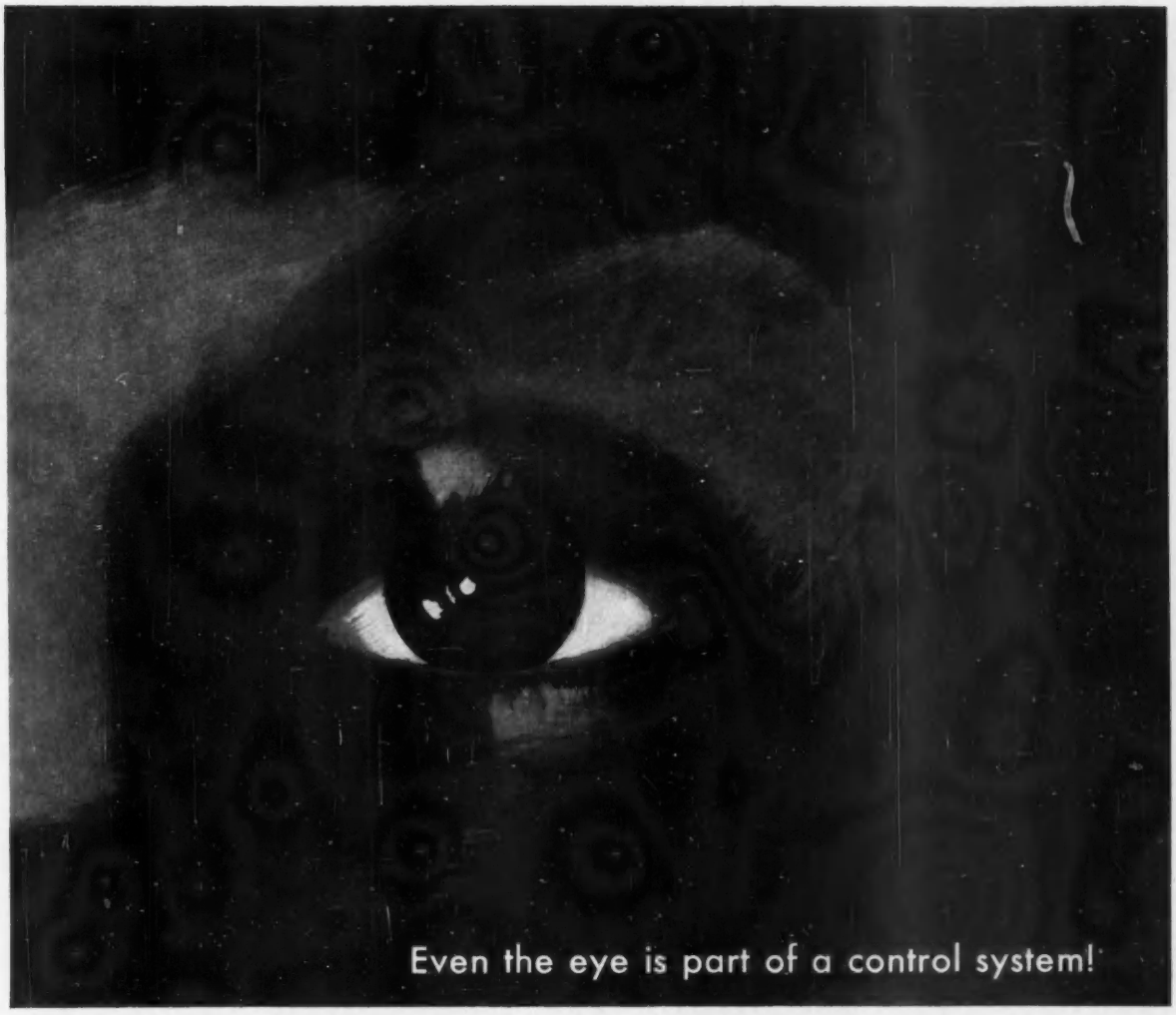
Barber-Colman Automatic

Complete saturable reactor temperature control by Model 407 Capacitrols of wire enameling ovens saves time, bother and heat energy. The appearance of the coatings is improved and abrasion tests show consistently higher coating resistance.



BARBER COLMAN

Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Electrical Components •



Process Control Systems

Wheelco sensing devices serve their control center just as the eye does. Light, heat, pressure, flow and other process variables are detected, measured, converted to self-regulating systems, and held within close limits by fine Wheelco instruments. Backed by twenty-five years of process control application, Barber-Colman can design a more profitable control system for your process. In the planning stage, call in a Barber-Colman, Wheelco Field Engineer to learn about the newest in instrumentation. His number is in the Yellow Pages.

WHEELCO INDUSTRIAL INSTRUMENTS DIVISION

Dept. L, 1548 Rock Street
Rockford, Illinois, U.S.A.

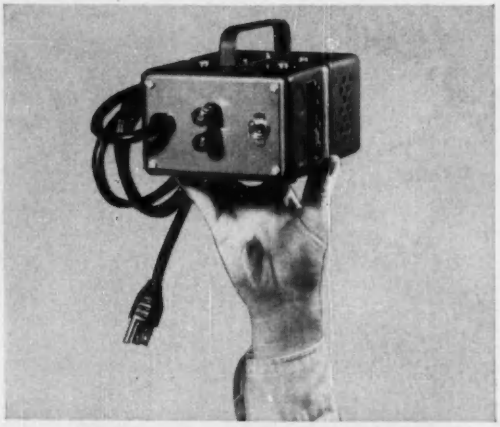
Barber-Colman of Canada, Ltd.
Dept. L, Toronto and Montreal, Canada

Export Agent: Ad. Auriema, Inc., N.Y.

BARBER-COLMAN COMPANY

Small Motors • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

Take your voltage supply where you need it with Sola's portable sources of regulated voltage



Portable filament transformer insures stable test conditions

This static-magnetic voltage regulator, with capacity of 30va, provides a stabilized output of 6.3 volts, automatically and continuously regulated within ±1% despite line voltage swings between 95 and 130 volts.

Since no variants are introduced by line voltage dips or surges, your experimental and test equipment is given a consistent reference datum against which it can yield reliable data on other variables.

The unit provides a high degree of isolation between input and output. Simple, rugged design eliminates moving parts, replaceable parts, manual adjustments, routine inspection and maintenance.

Handy in the laboratory or at the shop bench, it plugs into any a-c wall or bench outlet, and provides an on-off switch and output jacks.

Write for Bulletin CVF

Portable Solavolt power supplies give regulated a-c and d-c voltage for laboratory and test work.

A-C and D-C Solavolts regulate output within ±1% for line voltage variations as great as ±15%, with a response time of 1.5 cycles or less.

Output of the a-c model is fully adjustable from 0 to 130 volts, with less than 3% total rms harmonic content. This makes it ideal for instrument calibration, testing, or any operation involving elements sensitive to wave shape.

The d-c model consists of a special type of Sola Constant Voltage Transformer, semiconductor rectifier and choke. Ripple voltage is held within 1% rms at full load.

Solavolts have no replaceable parts, require no routine maintenance. They are portable for bench use, or may be mounted on a standard 19-inch relay rack.

Write for Bulletin CVL/DCL

Portable Televolt improves performance of TV sets, radios, hi-fi, tape recorders

This static-magnetic voltage regulator improves television reception by correcting line voltage variations which often cause picture flicker and distortion. It also stabilizes voltage for improved performance of high-fidelity amplifiers, radios and tape recorders. The unit regulates within ±3% of nominal for input voltages between 95 and 130 volts, to give a nominal fixed output within the range of 115-120 volts. Requires no installation—merely plug it in and forget about it. The compact Televolt is automatically switched on or off by a relay whenever the equipment power switch is operated.

Write for Bulletin 26J-CVA

SOLA

SOLA ELECTRIC CO.

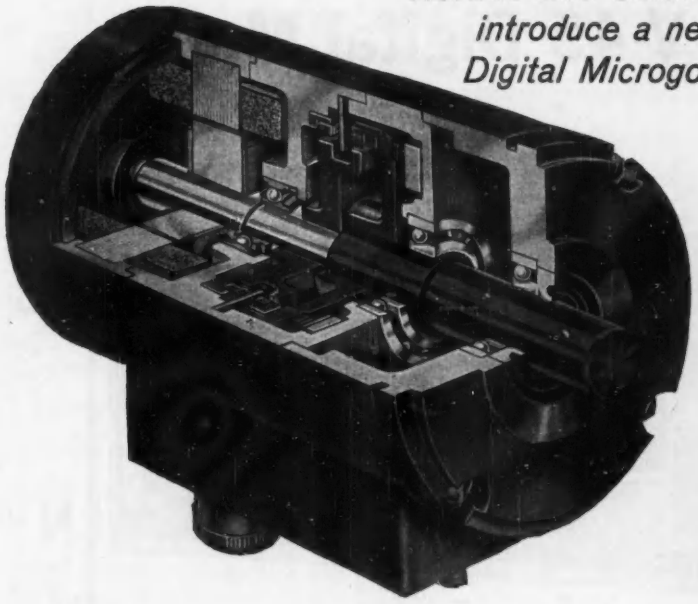
BPC

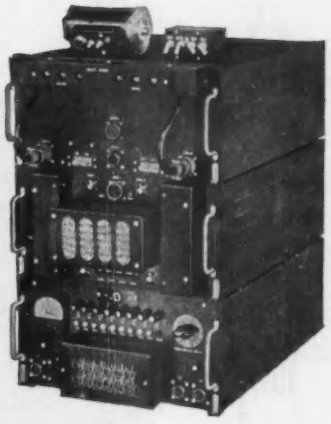
Sola Manufactures: Constant Voltage Transformers, Regulated DC Power Supplies, Constant Wattage Mercury Lamp Transformers and Fluorescent Lamp Ballasts

A Division of Basic Products Corporation

Busse Road at Lunt, Elk Grove, Illinois, HEmpstead 9-2800 • In Canada, Sola-Basic Products, Ltd., 377 Evans Avenue, Toronto 18, Ontario

Norden and Colorado Research introduce a new line of Digital Microgoniometers





HIGH ACCURACY ANGLE ENCODING EQUIPMENT

The Microgon Model 360/106 Angle Encoding Equipment . . . a complete electro-mechanical measuring system provides continuous decimal display of measured angle in degrees and thousandths of a degree. The success of the Microgon Model 360/106 now prompts Norden and Colorado to introduce a number of other high-accuracy, high-resolution Digital Microgoniometers designed for such diverse applications as missile launching and tracking, star tracking, radar antennae, radio telescopes and machine tool indexing and positioning. The following complete systems are offered:

MICROGON MODEL NO.	COUNTS PER TURN	CODE
360/106	360,000	8-4-2-1 binary decimal
512/218	262,144	Parallel pure binary
512/219	524,288	Parallel pure binary
2048/221-H	2,097,152	Parallel pure binary (hollow shaft)
1000/106	1,000,000	8-4-2-1 binary decimal
2048/221	2,097,152	Parallel pure binary (solid shaft)

TYPICAL CHARACTERISTICS OF THE MICROGON MODEL 360/106 SYSTEM

Total counts per Turn	360,000
Resolution	3.60 Sec. (0.001 Degree)
Accuracy At Any Point	3.6 Sec. Continuous Angle
Readout	(1) Visual Inline Decimal (2) Parallel 8-4-2-1 Binary Coded Decimal
Maximum Interrogation Rate	Limited only by associated circuitry
Maximum Shaft Slew Rate	Full accuracy at constant shaft speeds up to 100 degrees per second
Warm Up Time	10 Minutes
Operating Environment of Electronics	
Temperature	30°F to 110°F
Pressure	Sea Level to 17,000 feet
Vibration	Per Mil. E. 5400
Transducer Dimensions	3¾" Dia. 5.3" Long
Transducer Weight	Approx. 4½ Pounds
Transducer Moment of Inertia	3,210 gm-cm² (approx.)
Preamplifier Dimensions—Over-all	Approx. 4¼" Long, 3" High, 2⅛" Wide
Preamplifier Weight	15 Ounces
Dimensions each Module	21 11/16" Long, 15½" Wide, 7⅞" High
Reversible Degree-Decimal Counter Weight	35 Pounds
Power Supply Weight	66 Pounds
Dual Controlled Oscillator Weight	53 Pounds

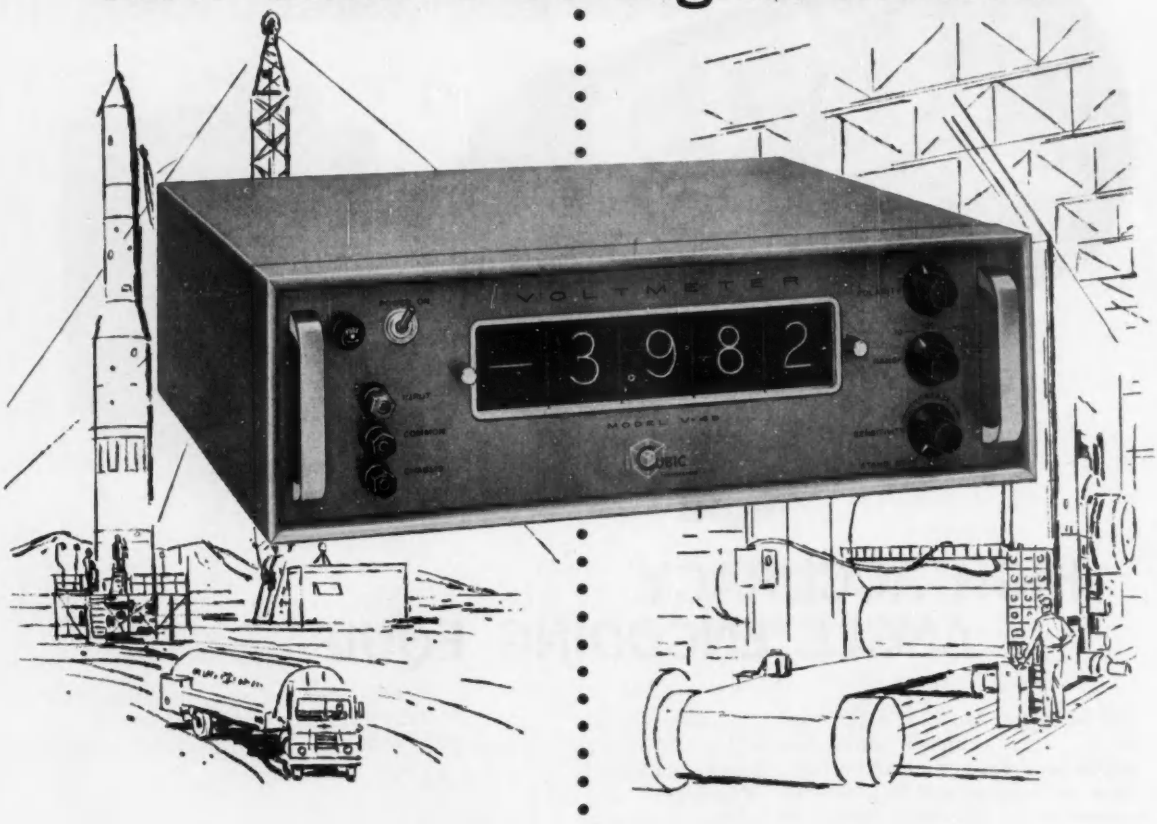
Please send for complete specifications on any of these high accuracy angle encoding systems, or any other Norden encoders. Write, or call Milford, Connecticut, TRinity 4-6721.

NORDEN

NORDEN DIVISION
UNITED AIRCRAFT CORPORATION
MILFORD DEPARTMENT, WILEY STREET, MILFORD, CONNECTICUT

CIRCLE 61 ON READER SERVICE CARD 61

New Cubic V-45 Digital Meters



Priced for Industry! Proven for Defense!

SPECIFICATIONS

Absolute accuracy: 0.02% ±1 digit (rms sum of system tolerances)

Input: Floating or grounded, from front panel connections.

Input impedance: 10 megohms at balance

Input filter: 60 cps rejection

Ranges: Manually selected, 10% expanded range

Low	±0.000 to ±10.999 vdc
Mid	±00.00 to ±109.99 vdc
High	±000.0 to ±1099.9 vdc

Sensitivity: 1 millivolt

Sensitivity control: continuous from 1 digit to 10,000 digits, with standby lockout.

Power input: 105-125 vac, 50-1000 cps, 20 watts

Dimensions: 19" wide x 5¼" high x 15½" deep, rack or bench mounting, with dust-proof switch and bridge section.

Now, at last, the top quality and dependability of Cubic digital voltmeters are available in a meter priced for the industrial market. It is the new four-digit V-45 Digital Voltmeter, fully transistorized, aecurate, economically priced.

The practical manager recognizes the costliness of operator errors through misreading and misinterpretation. These errors occur daily on the production line, in quality control, testing and receiving inspection. Alert managers are continuously seeking instrumentation which will eliminate the human element in measurement procedures.

The new Cubic Model V-45 Voltmeter is the answer. It offers the precision expected from custom-built equipment and covers the full d-c range from 1 millivolt to 1099.9 volts. It is rugged enough for operation in any industrial environment. Like all Cubic digital voltmeters, the V-45 features the proven reliability and accuracy of transistor-driven stepping switches.

Write for more information to **Dept. CE-2,** Industrial Division, Cubic Corporation, San Diego 11, California.

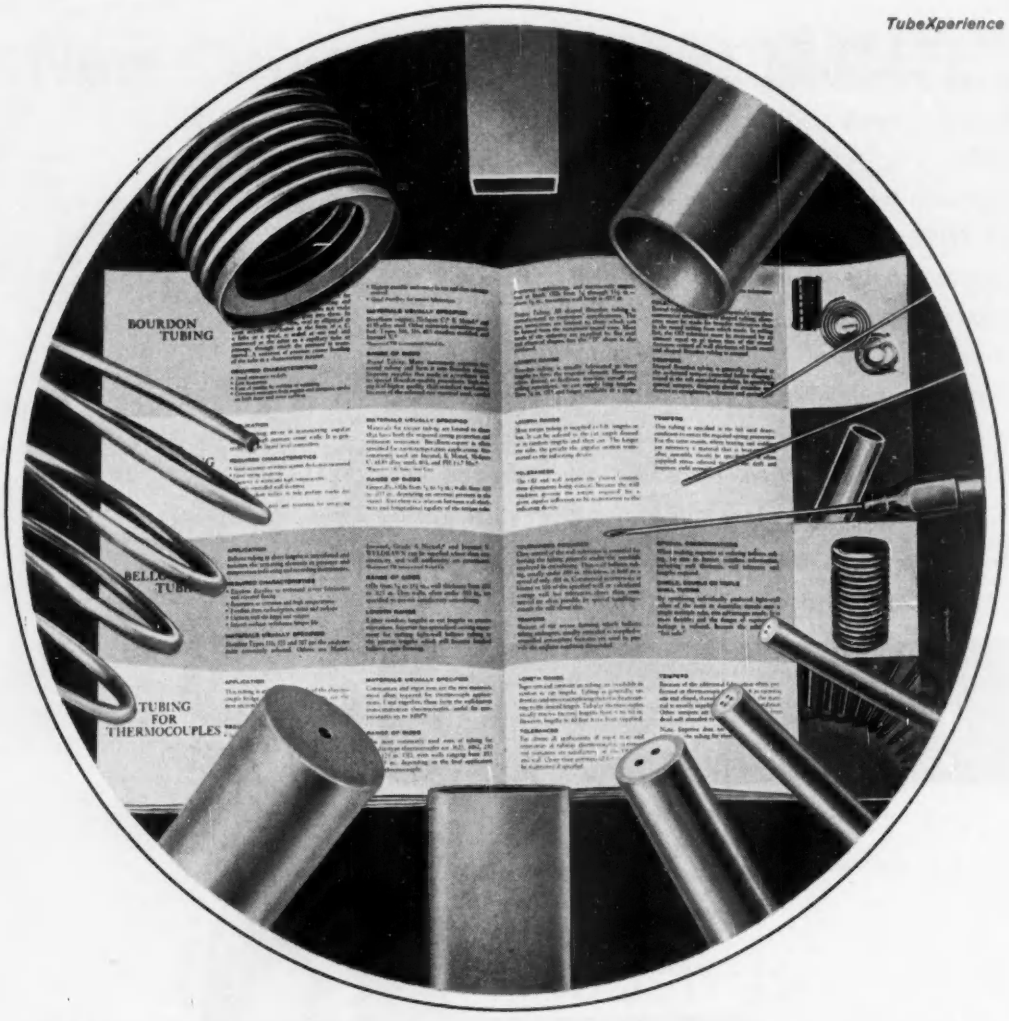
V-45 . . . the economy meter in a quality line, price $940.00

cubic CORPORATION

Think what a waltz life would be after you installed Benson-Lehner's OSCAR K record reading system. No more needless drudgery in slowly reading, interpreting and transcribing trace records...why, you could romp through your record reading chores with this complete, compact system...and it's only a mere $4990. The OSCAR K can read paper trace records, transparent trace records, and translucent or opaque film records with an accuracy of plus or minus 0.1% of full scale. It takes records up to 12-1/2" wide and 500 ft. long, in either direction at a motorized variable speed. Output is to Benson-Lehner's Electrotyper or IBM Keypunch. Your record reading would not only go faster and more accurately, but at so much less cost. So why not make music together? Just ask us.

benson-lehner *Corporation. Write us at 11930 Olympic Boulevard, Los Angeles 64, California.*

TubeXperience in action



TUBEXPERIENCE PREPARES A NEW INSTRUMENT BULLETIN —GUIDE TO SELECTION AND APPLICATION OF INSTRUMENT TUBING

Superior's long experience in producing small-diameter metal tubing to extremely close tolerances enables it to offer instrument designers and makers a wide variety of materials, sizes, metallurgical competence, and manufacturing skills that save experimentation in the design stage . . . time and cost in production.

"Specialty Tubing for Industrial Instrumentation"—a new bulletin by Superior just off the press—puts into print for the first time comprehensive information that covers all types of Superior tubing for the instrument field. It includes required characteristics, materials usually specified, range of sizes, tolerances, tempers, and special considerations for thermometer-bulb, capillary, Bourdon, bellows, fire detection, linkage, recording-pen and torque tubing; also tubing for thermocouples and gas chromatography.

Send for a copy of this valuable bulletin today. The information covered will greatly help your selection of tubing for all measuring, indicating, recording and control devices. If you have a problem involving tubing, call on us to help you solve it. Superior Tube Company, 2026 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

W5MT3A

new

METERED VARIAC® CONTINUOUSLY ADJUSTABLE A-C SUPPLIES

- ★ Ideal for measuring power consumption.
- ★ Convenient means for determining the effects of reduced or increased line voltage on a-c operated equipment; for example, locating cutoff points of voltage-regulator circuits.
- ★ Useful for tracking down circuit troubles that are intermittent with normal line voltage, but which can be made to occur more frequently or fail altogether at either low or high line voltage.

W5MT3AW

W5MT3W

These Metered Variacs are everyday tools needed in laboratory test setups and engineering work areas. Each model consists of a Variac with patented Duratrak* brush contact surface, a current transformer, the necessary switches and meters. Meters are magnetically shielded to yield an over-all accuracy of 3%. A double-pole off-on switch disconnects the instrument from both sides of the line. The output circuit has two fuses mounted on the front panel to protect both the Variac and its meters from overload.

*U.S. Patent No. 2,949,592

5 MODELS — 0 to 135 volts at currents to 10 amperes

	Type	Current Ranges	Wattage Ranges	Price
5-Amp Models	W5MT3A	0-1, 0-5	—	$89
	W5MT3W	—	0-150 0-750	$112
	W5MT3AW	0-1 0-5	0-150 0-750	$150
10-Amp Models	W10MT3A	0-2 0-10	—	$110
	W10MT3W	—	0-300 0-1500	$138

Write For Complete Information

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS

The Best Instruments In Electronics

NEW YORK, WOrth 4-2722
NEW JERSEY, Ridgefield, WHitney 3-3140

CHICAGO
Oak Park
Village 8-9400

PHILADELPHIA
Abington
HAncock 4-7419

WASHINGTON, D.C.
Silver Spring
JUniper 5-1088

SAN FRANCISCO
Los Altos
WHitecliff 8-8233

LOS ANGELES
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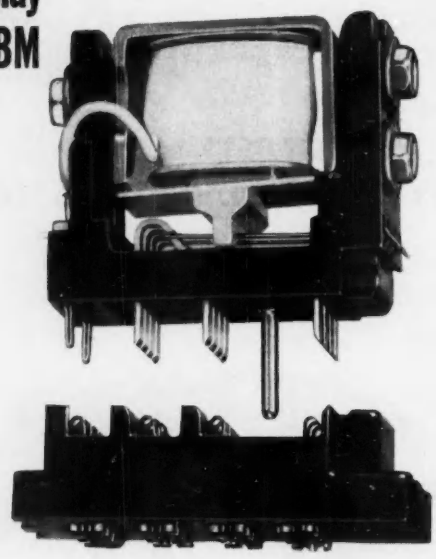
HOllywood 9-6201

IN CANADA
Toronto
CHerry 6-2171

CIRCLE 65 ON READER SERVICE CARD

New Relay from RBM



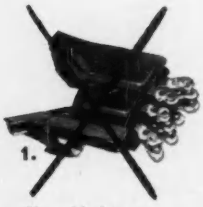
Compact, Rugged, Proven Reliable

THE DIRECTOR

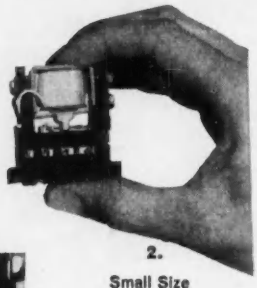
TYPE 81 WIRE CONTACT RELAY

Specifically designed to direct or set-up circuits in the logic or arithmetic section of computer and business machines. The RBM "Director" has also demonstrated itself ready to perform in similar applications where the basic function of the contacts of one or more relays sets up a circuit, but is not required to make or break that particular circuit. Typical uses would be controls for automation, railway signaling, traffic controls, chemical process controls, announciators and many others.

Designed for high speed and long life (200 million operations).



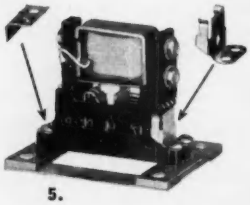
1. No soldering



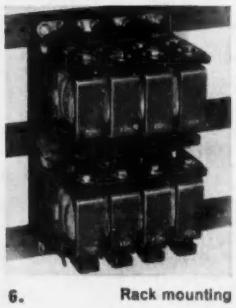
2. Small Size

3. Wire contacts

4. Program connectors



5. Rugged snap-in plug assembly



6. Rack mounting

1. Plug-in terminal and mating terminal block eliminates messy soldering and maintenance problems of old fashioned telephone type relays.

2. Symetrical shape and rugged design provides for minimum mounting space and maximum protection to moving parts when handling.

3. Armature contacts consist of two silver alloy wires per pole providing highly reliable redundant contact surfaces.

4. With plug-in connectors "A" relay contacts can be "programmed" to suit specific circuit requirements.

5. Special hardware available allowing for mating terminal block assembly and easy mounting on chassis or rack.

6. The Type 81 relay can be easily assembled in groups, simplifying wiring and ease of programming. Requires minimum rack or chassis space.

TYPE 81 SPECIFICATIONS

Contact Form	4 PDT
Contact Rating	3 amp. (carry only)
Contact Material (Std.)	Eutectic Alloy—Silver-Copper
Operating time (Nom.)	5.5 milliseconds max. inc. bounce
Life	200 million operations
Coil Form	Single or Double Winding (Pic & Hold)
Coil Voltage	20 volts D.C. thru 115 volts D.C.
Coil Power	4 watts max.
Breakdown Voltage	1250 volts RMS 60 cycle to frame
Ambient Temperature	50° C
Weight	Approximately 1¾ oz.
Overall dim. (Approx.)	Including plug—2 1/16" x 5/8" x 2"

Consult Your Local RBM Product Application Engineer or Write for Bulletin 2000

CONTROLLING RBM QUALITY THE FUTURE

RBM Controls Division

ESSEX WIRE CORPORATION, LOGANSPORT, INDIANA

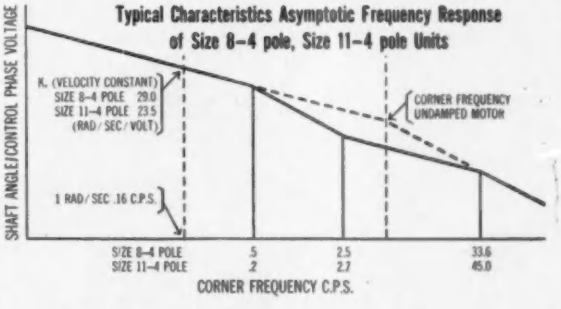
Factories Located at North Manchester and Logansport, Indiana

inertially damped servo motors

Thirteen lucky solutions to stability problems! Transicoil's complete new line of acceleration (inertially) damped servo motors matches every conceivable requirement with performance far in advance of previously available models. You can have size 8, 11, 15, or 18 . . . in 4, 6, or 8 poles . . . standard or high torque . . . corner frequencies cut to your special needs. And if necessary, an endless variety of special motor windings and shaft configurations. Highest 3rd corner frequency available in industry assures excellent system frequency response. Also, the large difference between the 2nd and 3rd corner frequencies simplifies amplifier stability requirements.

Using these new damped motors in a system you can operate at higher gain, with less position or velocity error, less backlash sensitivity, increased stability. They're far superior to damping generators in marginally unstable systems. And compared to viscous damping or rate feedback, permit high slewing speed, consume less power, generate less heat, require less wiring, and need no warm-up period.

SPECIFICATION SHEETS on the complete line are available now on request. Or, just tell us your problems and we'll do our best to come up with a solution.



Foreign: Daystrom International Div., 100 Empire St., Newark 12, New Jersey. *In Canada:* Daystrom, Ltd., 840 Caledonia Rd., Toronto 19, Ontario.

DAYSTROM, INCORPORATED
TRANSICOIL DIVISION

WORCESTER · MONTGOMERY COUNTY · PENNSYLVANIA

CIRCLE 67 ON READER SERVICE CARD

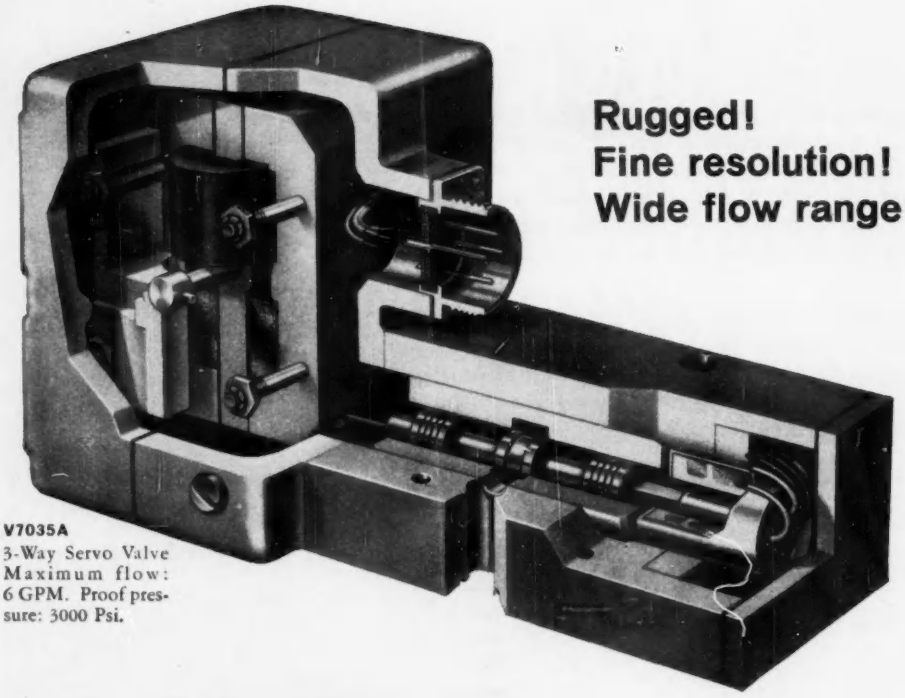
PROOF OF HIGH PERFORMANCE ...LIBRASCOPE DIGITAL COMPUTERS

High performance for leading business, military and industrial systems is displayed in this presentation of Librascope's digital computer family. They offer an extension of man's expanding mind, allowing achievements which only a few years ago were far beyond his reach. Librascope engineers are developing still more outstanding computers which will employ the most advanced techniques of logical design, packaging, memory systems and display.

Advanced research teams and continuing product improvement studies assure highest reliability and performance of all systems and components. The Company's 23-year history encompasses an unrivaled scope of varied analog and digital computers, a background which has produced many industry "firsts" and further demonstrated that Librascope means leadership in computers.

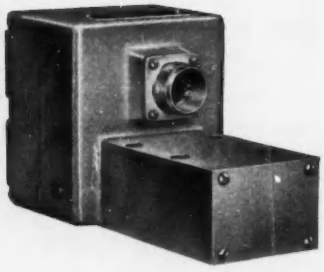
1—**LGP-30,** 4096-word drum memory
2—**LIBRATROL-500,** 4096-word drum memory
3—**ASN-24,** 2048-word drum memory
4—**CP-209,** 3000-word drum memory
5—**RPC-9000,** 10,000-unit record tape storage plus modular delay line memory for working storage
6—**MARK 38,** 512-word drum memory
7—**AIR TRAFFIC CONTROL,** 4000-word core memory, plus 256,000-word modular drum memory system
8—**LIBRATROL-1000,** 8000-word drum memory
9—**RPC-4000,** 8000-word drum memory
10—**MARK 130,** 4096-word core memory

*Trademark, Librascope Division, General Precision, Inc.
†1, 5 and 9 are marketed through the nation-wide sales offices of Royal McBee.

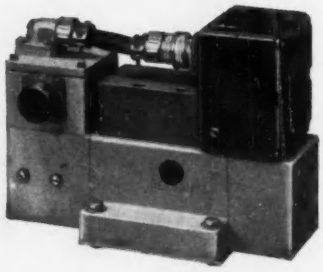


Rugged!
Fine resolution!
Wide flow range!

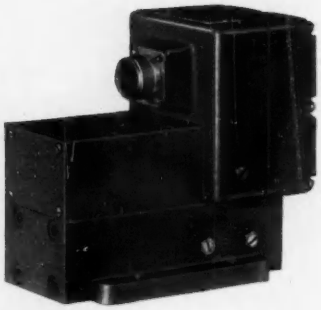
V7035A
3-Way Servo Valve
Maximum flow: 6 GPM. Proof pressure: 3000 Psi.



V7037B
4-Way Servo Valve
Maximum flow: 4 gallons/minute at 1000 Psi. Proof pressure: 3000 Psi.



V7040A
2-Stage Servo Valve
Maximum flow: 40 gallons/minute at 1000 Psi. Proof pressure: 3000 Psi.



VJ307A
2-Stage Servo Valve
Maximum flow: 15 gallons/minute at 1000 Psi. Proof pressure: 3000 Psi.

Honeywell SERVO VALVES

Now Honeywell offers you a complete line of electro-hydraulic servo valves designed to meet any industrial application, built to withstand all industrial environments.

Honeywell Servo Valves feature integral LVDT electrical feedback to give you the widest spring-rate selection available. Their new rate action assures greater inner-loop stability. They have a low hysteresis, low threshold, high speed of response and almost infinite resolution. They are torque actuated and can be mounted in any position. And, they have *only one moving* part so that maintenance is practically eliminated.

Used with Honeywell amplifiers, commands, feedbacks, actuators and other complementary equipment in an all-Honeywell electro-hydraulic servo system, Honeywell Servo Valves provide the most dependable, efficient machine control possible.

For complete information about Honeywell Servo Valves, call your local Honeywell office. Or write Honeywell, Dpt. CE-12-87, Minneapolis 8, Minnesota.

Honeywell

First in Control

SINCE 1885

75th YEAR — PIONEERING THE FUTURE

How to get accurate data on a small recorder

Ampex's new CP-100 nicely balances four desirable qualities

Compact. Definitely, and a great advantage in trailers, in airplanes, in submarines, or even in regular laboratory use. There's complete front access to everything. All-transistor amplifiers and power supplies cut power needs and keep down the heat – an advantage in tight equipment layouts.

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Precise. Let the numbers talk. Though compact, the CP-100 is a full-fledged, uncompromised laboratory recorder: 200 kc response at 60 ips tape speed (and proportional at others); flutter well within telemetered-data requirements; intermodulation distortion so low it never adds spurious data of its own.

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The essential data

Model: CP-100 Compact Recorder/Reproducer. *Reel size and tape width:* 10½-inch reels with ½- or 1-inch tape (as specified). *Types of recording:* direct or FM carrier by plug-in interchangeable amplifiers. *Tape speeds:* 60, 30, 15, 7½, 3¾ and 1⅞ ips. *Frequency response:* direct, 300 to 200,000 cps ± 3 db at 60 ips; FM carrier, 0 to 20,000 cps at 60 ips; response at other speeds proportionate. *Tape compatibility:* yes, with Ampex FR-600, AR-200 or interchangeable with FR-100, FR-1100, 300 and 800 series.

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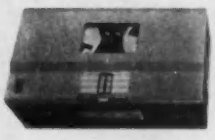

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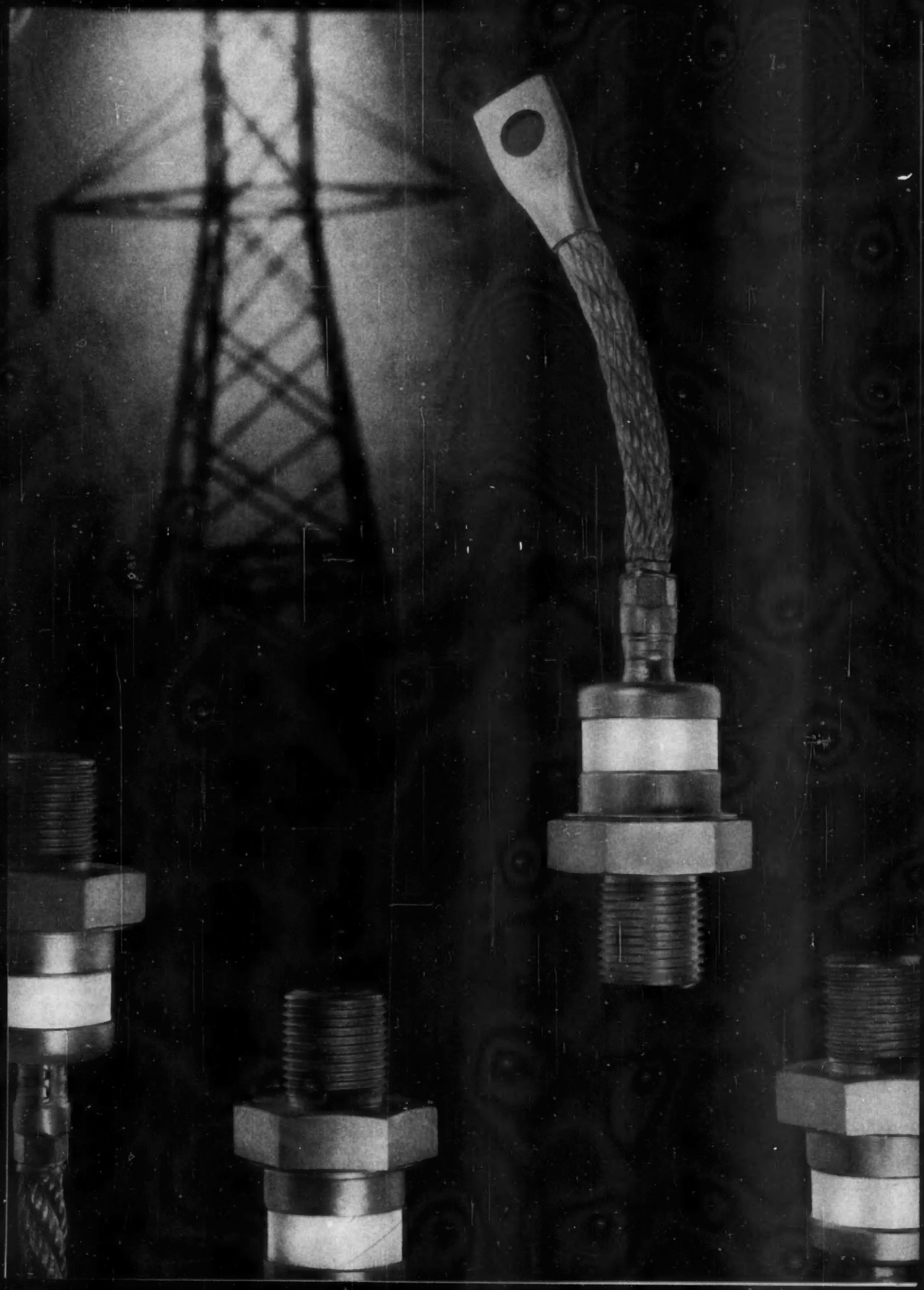

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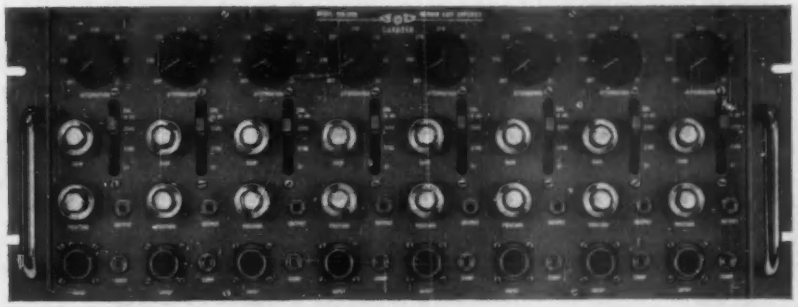

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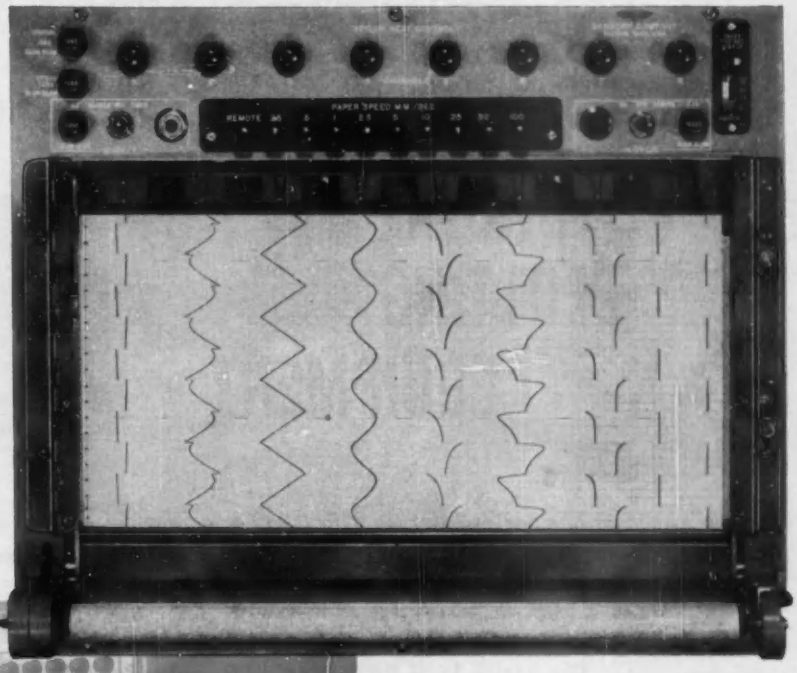

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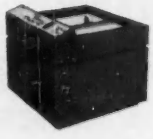

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The Crisis We Face—
A Rebuttal by the Military

Reviewer William L. Still, one of the new breed of technically-minded military men.

(Editor's note: In October the McGraw-Hill Book Co. published a controversial book entitled The Crisis We Face—Automation and the Cold War *written by George Steele and Paul Kircher. It is a bitter condemnation of the present U.S. military effort on the basis of "too much complexity in automation equipment". One of its pet whipping boys is the Minuteman project, the Air Force's solid propellant ICBM. Because of the torrid criticism of the control field, particularly as applied to Minuteman, CtE asked Major William L. Still, Chief, Ground Equipment Branch, Minuteman Program Office, to review the book. Major Still not only refutes the authors' contentions, but he also presents a revealing picture of the Minuteman project. The views expressed by the author are his own and do not necessarily represent those of the United States Air Force.)*

". . . More than eighty percent of the total cost of a missile base is now in ground equipment. The strange decision not to produce our ICBM once we had it (as a result of a fantastic crash program) was made because Atlas cost $10 million and Minuteman would cost only $1 million. Obviously Minuteman could be free, and still cost eighty percent of the Atlas . . ."

". . . As these costs (of Minuteman) approach those of Atlas and Titan, every effort will be made for increased accuracy to justify high costs (fantastic with 300 lb. hard sites) . . ."

". . . Military leaders are now belatedly undertaking the 'hardening of missile bases' . . ."

These are a few examples of irrational and irresponsible statements made within *The Crisis We Face—Automation and the Cold War*. The lack of logic of the first statement is so obvious it is refutable by seventh grade arithmetic. The next two statements, considered together, are much more insidious. First we are damned if we harden sites, and we are damned if we don't. Second, they imply complete stupidity and intellectual dishonesty, if not criminal subjugation of the facts.

The book attempts to prove that we, as a country, are automating ourselves into the position of a second class military power and into economic chaos. The cause is not automation itself, but the existing management approaches to its implementation. The central theme is that automation should be treated as an entity, inspired, designed, and imposed as a package.

Piecemeal automation, by breaking it into manageable units, tends to breed hypercomplexity through duplication of automatic functions and data inputs. The separately developed devices are frequently incompatible. Connection introduces even more complexity.

As the authors see it, complexity breeds additional complexity because of high parts counts which generate increased failure rates. Redundant circuits are added. These increase mean times between equipment outages but add to already high parts counts, and failure rates become even higher. Maintenance outages become longer, so automatic checkers are developed (again increasing parts counts), then checkers to check the checkers, and spiraling complexity increases.

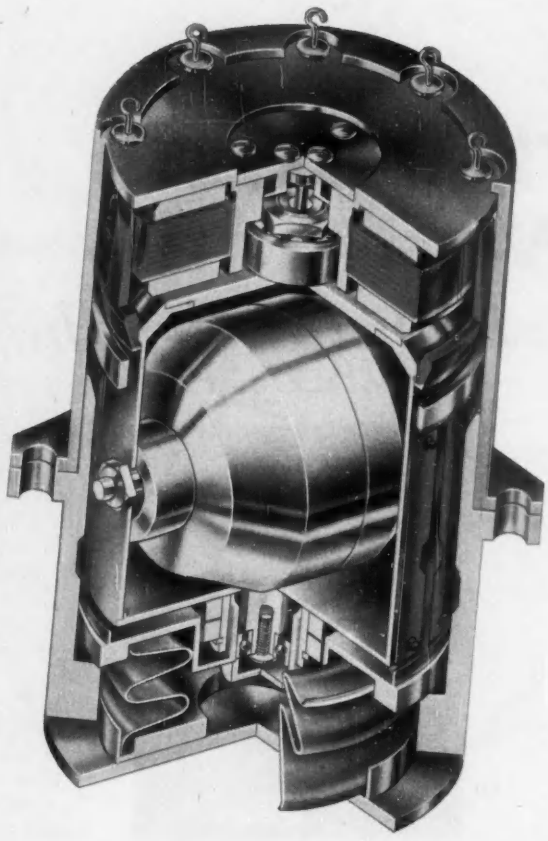
A lost cause?

It cites examples from the Atlas missile program and from there extrapolates to Minuteman. After concluding that Minuteman is a lost cause, the authors range far afield, covering such diversified topics as hypercomplexity in business automation; need for leadership; Admiral Hyman Rickover as an example of the type of officer needed; decision making processes; war—past, present, and future (its planning, strategy, gaming, and execution); computer design philosophy; Russian training and leadership; and education for automation. They analyze and solve the problems they pose.

Some of the authors' long range solutions to the

Ketay 2″ floated rate gyro controls damping from −54° to +74° C.

... saves space, weight, wattage and wear



Ketay has been successful in developing a floated rate gyroscope with a unique bellows and spring fingers system which compensates for temperature changes. Fluid viscosity is allowed to change freely, while the damping gap is controlled instead. This ingenious shear damping principle offers true "second order performance." No heating is required from −40° to + 74° C.

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TYPICAL RG 20 SPECIFICATIONS

Rate (deg/sec)	±30
Natural Frequency	25 cps (min)
Size	Diameter 2″ Length 2⅞″
Damping (Ratio to Critical) over temperature	.07 ±0.2
Spin Motor	115V Line to Line 3φ 400 cps
Pickoff Type	Inductive
Excitation	26 VRMS 400 cps
Sensitivity (v/deg/sec)	0.2
Threshold (deg/sec)	0.06
Weight	1¼ lbs. (max)

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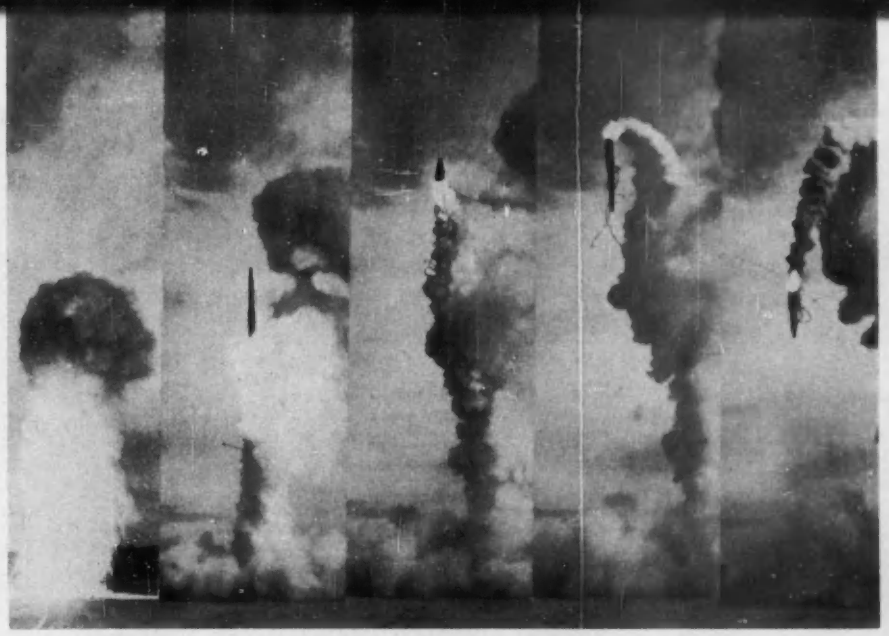

Minuteman, ahead of schedule, in a tie down test of its first engine stage.

problems of automation warrant thoughtful consideration. For example they feel that automation has grown to a point where it should be recognized as a profession in its own right. It requires a broad background of training. Automation must, eventually, cut across disciplines and integrate in such a manner as to achieve the specific goal of the process to be automated. A specialist in automation must be a generalist conversant with many fields such as automatic control, scientific development, computers, data processing, management, and economics. The authors even outline a seven-year college course to accomplish this goal.

In the final chapter the authors present an analysis of our defense. I find I cannot be objective about this chapter. There is a vast amount of data, of varying authenticity, presented. The subjective picture drawn by this, if true, would be disastrous.

After a superficial review a reader is left with the impression that: our military and economic leaders are blind, stupid, and incompetent; our educational system is self-serving; all Russians are 10 feet tall; and that all of these problems can be solved by a proper approach to automation. The book is typical of a class of books and articles being published, with minor variations. The identical theme could be (and probably has been) written by an educator—the solution, education; by a labor expert—the solution, better labor relations; and so on throughout all the various specialized fields. Each would be partially right.

An important point, not mentioned, is that the military cannot afford the luxury of philosophizing in day-by-day operations. Our weapons systems must be built in the environment as it exists today, not as we would like to have it. Our tools for decisions and development are the world situation and scientific facts as known, people of high specialization and limited breadth, people of great breadth and limited specialization, and organizations either efficient or inefficient, as they are available.

Debunking the authors

I will point out a few discrepancies, half-truths, and misstatements that the authors have made about Minuteman and describe what the situation actually is.

In extrapolating from Atlas to Minuteman the authors start with automatic checkout equipment. They state:

". . . In appraising the growth towards double saturation, note the maintenance checker for the operational Atlas missile (a device called APCHE) fills a building with equipment. It requires for its own maintenance about seventy-five men. The checker-checker (called CAPCHE), as yet unfinished, may yet prove to be still larger . . ."

The Minuteman guidance system is all inertial and is controlled by a high speed digital computer. Since the computer does not need its full capacity except in the flight mode, it is used to check itself and the rest of the missile. While stored in the alert condition, it continuously checks minor loops and, on specific commands from the Launch Control Center, performs a complete airborne system test; and it even recalibrates itself and the guidance unit. Minuteman has no APCHE.

Concerning the command and control problems of Minuteman, the authors say,

". . . In order to advance from a single missile (e.g. Atlas) to the automatic set of missiles (e.g. Minuteman), it is evidently necessary to make two major extensions of automation. First, all control and monitoring personnel now involved must be replaced. Second, a central system of computation and communications must be set up which can coordinate the joint action of the entire set . . ."

Replacement of personnel is one of the Minuteman goals; people cost money.

Command and control of the missile originates in the Launch Control Center, the manned post from which two men can govern all missile functions. The message structure to control the automatic force consists of a total of six commands transmitted from the Launch Control Centers.

Data must be fed back from the missiles. The authors state,

". . . The central system must be able to verify actual operability of every missile within the set at all times. This means complete and detailed automatic checkout conducted remotely . . ."

Actually only go/no-go conditions are monitored. Less than a dozen discrete status signals are returned from the missile. Some of these include:

THOMAS A.

EDISON

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The bearings of Con Edison's auxiliary equipment, ranging from main boiler feed pumps to coal pulverizing mills, are monitored by Thomas A. Edison resistance temperature detectors which are connected to Omniguard monitors located in the main control room. If any one of the 200-plus bearings monitored begin to overheat, an alarm is sounded instantly, the trouble area is identified on the Omniguard panels, and prompt corrective action is taken. Thanks to Omniguard, trouble is detected *before* damage can be done—which not only increases bearing life but slashes Con Edison's over-all maintenance costs as well.

Any industry can enjoy the complete, continuous protection that Omniguard provides. For complete information on your particular requirements, call or write:

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1. "Strategic alert"—indicating the missile is ready to launch.

2. "No-go"—indicating a malfunction which would preclude launch.

3. "Alarm"—indicating a malfunction which would not preclude launch but could, if left alone, generate a "No-go".

4. "Test in process"—indicating response to test commands.

5. "Calibration in process"—indicating response to calibrate commands.

6. "Outer zone security violated"—indicating that someone has penetrated the area surrounding a remote launch site.

7. "Inner zone security violated"—indicating that someone is seriously attempting to enter the secure, hardened missile site.

These are sufficient to illustrate the monitoring philosophy used for the system. Only those messages are fed back from the missile which indicate changes of programmed status or unprogrammed events which evoke a unique response from the manned portion of the system.

The authors then consider missile targeting:

". . . The central system must be able to select patterns of targets to satisfy a variety of parameters. It must assign targets to missiles and monitor the complete launching operations, all at high speeds . . ."

For obvious reasons I can only assert, not establish, that this is not the case.

Unfortunately they are correct when they state,

". . . Communication must be virtually infallable and incapable of being sabotaged. It must operate after we are attacked. This implies redundancy and complexity . . ."

This is inherent for survival. It is the same whether the system is manned or automated. Actually the simplicity of our automated message structure gives us a tool to eventually solve this problem. Recently a subcontract has been let for a radio launch control system for Minuteman. We cannot hope to meet the first deployment with this equipment because time is too short, but it is estimated that this advance, when integrated at a later point, will save from one-quarter to one-third of a million dollars per missile.

A measure of the complexity, or lack thereof, attributable to automation in the ground equipment can be given in the over-all count of equipment racks used in the system. The Launch Control Center controls the force with a total of three standard equipment racks. Launch sites will have from four to five each. It should be emphasized that this represents total electronics, miniaturized, but not subminiaturized. Some of this equipment, but by no means all, would not exist if automation were completely eliminated.

I might add, to support some of the points brought out by the authors, that if knowing what we know now, we had to do the whole job over, I would certainly recommend incorporating many of the functions presently in the ground equipment into the computer logic. Such action would probably achieve a substantial increase in simplicity. This tends to substantiate one of the book's rules for good computer design,

". . . Keep the design on paper and out of the laboratory as long as possible. The time devoted to study of the problem, and to search for ingenious solutions, has a much greater payoff than in other kinds of design work . . ."

This is correct. The longer you work on simplifying a problem, the better equipment you will have—*some time in the future.*

We are two years smarter than we were when we froze major design concepts. We are also two years nearer operational hardware.

The reliability program

The authors take a long look at their assumed parts count for Minuteman and attack our component reliability program. They say,

". . . Estimates have shown also that breakdowns in present electronic gear occur about one-third in components, one-third in engineering, and one-third in maintenance. This means that even if the components and engineering were improved a hundred times, but the maintenance only doubled, the net average increase in reliability would be less than seven times . . ."

After a discussion of the problems in reaching our goals they state,

". . . It can be concluded the Minuteman, as contemplated, is a lost cause."

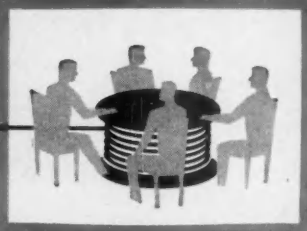
The logic of the first statement fails to pass the test of simple arithmetic. In the Minuteman case we do not anticipate maintenance for its own sake. Therefore a part must fail for some other cause before additional unreliability can be induced by maintenance. Try this simple exercise using the authors' own data: 1,000 parts fail—667 failures are due to components and engineering; 333 failures are due to maintenance. Now increase the reliability of components and engineering 100 times. Of these thousand parts which would have failed, only seven parts now fail. These parts could be thrown away and the over-all reliability would have increased by a factor of 140.

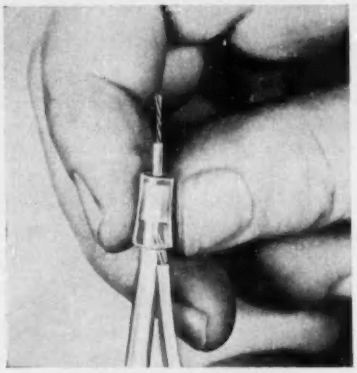
The authors indicate that some of our components will have to have mean times to failure on the order of 10,000 years. They then state,

"In order to test such components, and verify that such a level of reliability has, in fact, been achieved, it is

Ground support console for Minuteman. Launching requires just two men.

WIRE AND CABLE ROUND TABLE





One-piece Burndy connector gives fast, reliable compression

Fast and reliable connections are possible with the one-piece UNIRING, molded of ZYTEL by the Burndy Corp., Norwalk, Conn.

Since these are compression connectors, there is no heat needed, and thus no danger of overheating cable. This also means no slow, bulky solder joints. The completed UNIRING assembly is only a few mils larger than the cable diameter.

UNIRING is available both insulated and uninsulated for single shielded cables, multi-conductor shielded cable and coaxial cables. They are also color coded for easy identification.

The Burndy sheath connectors are another example of the versatility possible with ZYTEL nylon resins. For more information to help you evaluate ZYTEL for your needs, write to the address at the right of this page.

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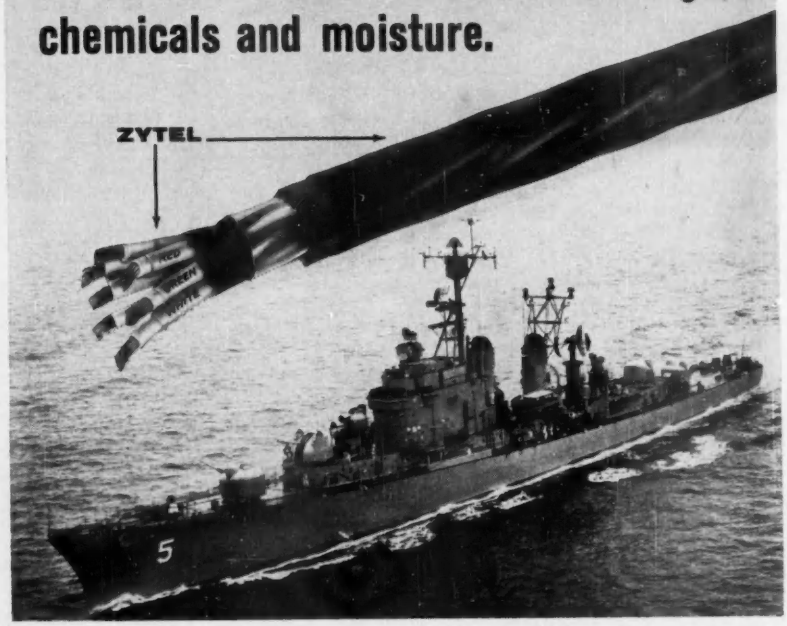


This naval destroyer, the USS Wilkinson, is equipped with modern, anti-submarine missiles controlled by cables protected with Du Pont ZYTEL nylon resin. (OFFICIAL U.S. NAVY PHOTO)

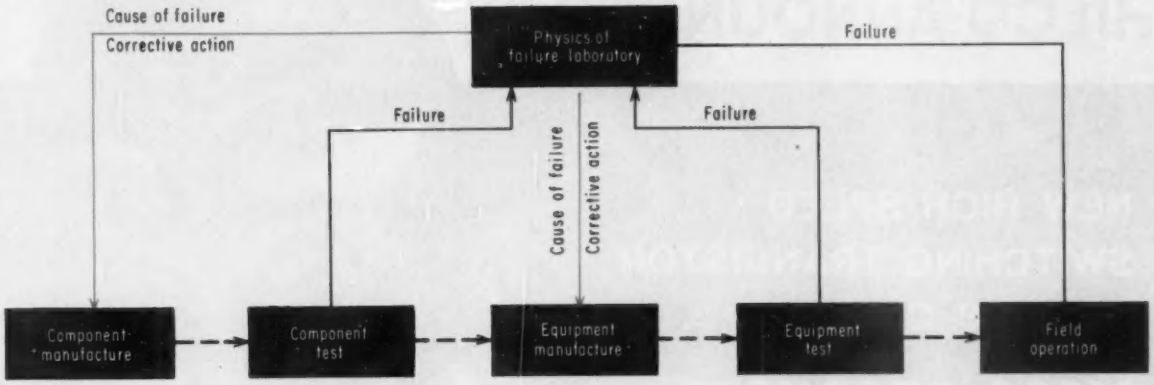
ZYTEL 33 and 37X help protect the Navy's "MOHOS" cable used to control the Mark 108 rocket launcher on the USS Wilkinson. In this new cable design, each single has a thin secondary insulation of clear ZYTEL 33, plus a tough outer armor of heat and light stabilized ZYTEL 37.

The two layers of ZYTEL are used for several important reasons. The armor protects the entire cable and allows it to be easily pulled through cableways without snagging or skinback. The two layers also provide outstanding resistance to cut-through, moisture and various hydraulic fluids to which the cable is exposed.

Because of the superior mechanical properties of ZYTEL, the jacketing is thinner than other materials could be, reducing the overall cable weight and diameter. The secondary insulation of ZYTEL 33 permits the effective use of watertight terminal lugs to prevent wicking. And its transparency allows easy reading of identification matter printed on the singles.

You may find that the use of ZYTEL nylon resins or other Du Pont wire and cable grade plastics can solve your problems. If you would like more information, consult your wire and cable supplier, or write to the Du Pont Company, Dept. E-12, Room 2507Z, Nemours Bldg., Wilmington 98, Delaware.

ALATHON® POLYETHYLENE RESINS | **RULAN®** FLAME-RETARDANT PLASTICS | **ZYTEL®** NYLON RESINS



Flow diagram of Minuteman reliability program.

necessary to test batches of approximately half a million units each, over a period of 1,000 hours. This implies that a single test will cost several million dollars."

Reliability cannot be tested into components. Even after establishing such data it still doesn't tell how to improve on what is available.

A new approach has been instituted which operates on dynamic test data. Each failure is treated independently. A failed component is sent to what is known as a Physics of Failure Laboratory, along with any available data, such as operating life and history of its particular manufacturing lot. The cause of failure is determined and corrective action taken.

The figure above illustrates the procedure. A component is manufactured and goes through a series of tests. Any failure is analyzed, and corrective action is taken in the manufacturing process. Components which pass the tests are incorporated into manufactured equipment, and the complete unit is run through a series of tests. Failures at the equipment level again go through Physics of Failure analysis and the cause is determined. These are categorized as component failure, manufacturing failure, or engineering design deficiency; and, again, corrective action is initiated. This procedure is continued in the field with operational units. It is presently planned that, initially, no Minuteman high reliability circuit cards will be repaired until after passing through the Physics of Failure Laboratories.

By taking all possible known preventive steps from initial component manufacture, and operating on the premise that there is no such thing as a random failure, we can gradually improve manufacturing, engineering, handling, and operating procedures to approach our reliability goals.

The Minuteman parts count is high. A launch site will contain approximately 60,000 parts. For Atlas the authors quote 6,000 transistors in the airborne equipment and 60,000 in the ground equipment. They estimate a ratio of 17 parts to one transistor to obtain the over-all parts count. If we use their figures, this would indicate that Minuteman, even with its complete automation, represents a simplification of almost 18 to 1. I have made no attempt to verify the authors' numbers, nor do I even know if we used the same ground rules in obtaining parts counts. Superficially it would seem that the authors' claim of Minuteman complexity piling on complexity have been refuted.

It would be unfair to the authors to leave the subject of Minuteman automation without pointing out where I believe they went astray in their analysis. Apparently by the time the authors recognized the trend of spiraling complexity, the "incompetent" military had already analyzed the situation and decided to do something about it. Minuteman is the result of this decision. The authors' extrapolation of first generation systems to Minuteman would probably have been correct except for this decision.

Lead times versus lag

The authors review some of the broader aspects of weapons system planning. They condemn us for attempting to compress schedules. At the same time they also decry the fact that development lead times have grown until a weapon is obsolete before it has finished the development stage. They state,

". . . In each case there was a major and persisting procurement error. There was the explicit assumption that great simplicity, extraordinary accuracy, and short time schedules could all be contracted for without harming the resultant activity . . ."

". . . At present there are estimates of about seven to ten years for our lead time, and about half that for the Russians. The major reason for our lag is the hierarchy of delay circuits in our organizational system. After a design becomes technically feasible, it takes as much as five years for scientists to sell it to our administrators, who, in turn, must put it on our budget assembly line . . ."

The whole concept of concurrency under which the Minuteman is being developed is dedicated to reducing this time lag, something which the authors say cannot be done and still deploy a workable system. It would be well to conclude by checking milestones to see if there are any indications that we will fail to meet both our technical and schedule commitments.

Announcements have been made that Minuteman is as much as 18 months ahead of schedule. The first complete test missile will fly before the end of the year. In May 1960 the Air Force completed the eighth successful firing from underground launchers out of eight attempts. This program was so successful that the remaining 10 scheduled test launchings were cancelled. Plans have been completed for the first 150 Minuteman sites; in fact, the last of these sites are to be completed in May 1962. Does this look like the schedule for a system which will not be operational until 1965—as stated by the authors?

—William L. Still

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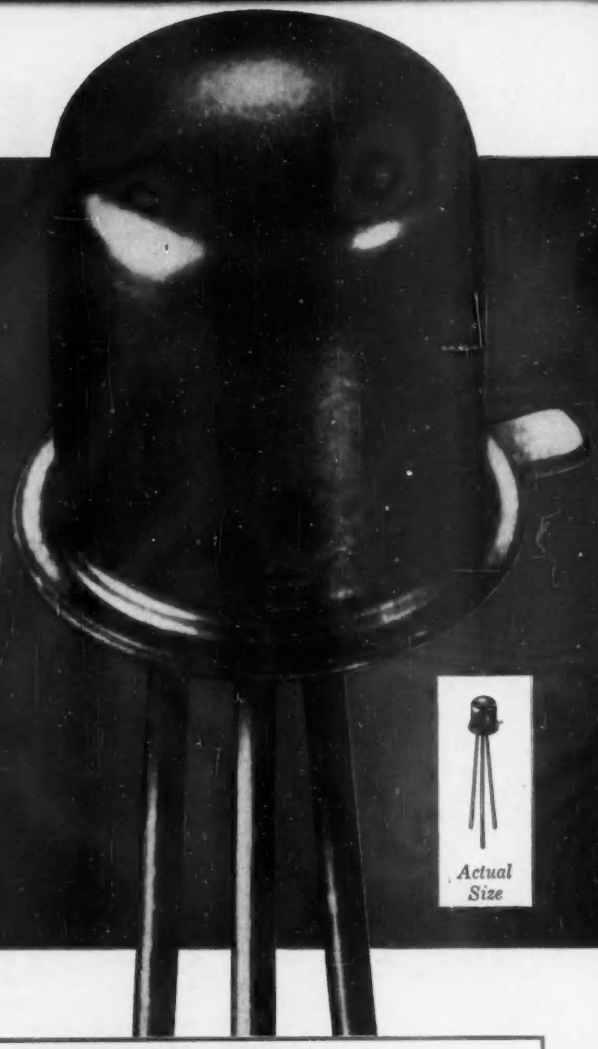

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Total Device Dissipation at 25°C	60 mw

ELECTRICAL CHARACTERISTICS (T=25°C)

	Min.	Typ.	Max.	
Static Characteristics				
Collector Cutoff Current, I_{CBO} (V_{CB} = −5v)		1.0	3	μa
DC Current Amplification Factor, h_{FE} (V_{CE} = −0.5v, I_C = −10 ma)	50	90	200	
Base Voltage, V_{BE} (I_C = −10 ma, I_B = −0.5 ma)	0.29	0.33	0.36	volt
Collector Saturation Voltage, V_{CE} (SAT) (I_C = −10 ma, I_B = −0.5 ma)	.09	0.12	0.16	volt
High Frequency Characteristics				
Output Capacitance, C_{ob} (V_{CB} = −3v, I_E = 0, f = 4 mc)		1.9	2.5	μμf
Input Capacitance, C_{ib} (V_{EB} = −1v, I_C = 0, f = 4 mc)		6.0	10	μμf
Gain Bandwidth Product, f_T (V_{CE} = −5v, I_E = 7 ma)	320	450		mc
Switching Characteristics				
Rise Time, t_r (β_C = 10)		13	18	mμsec
Hole Storage Factor, K'_s		39	50	mμsec
Fall Time, t_f (β_{CB} = 10)		10	18	mμsec

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DECEMBER 1960

Open Books Open Minds

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We wonder how people will know that you have a store of special knowledge and what will prompt them to beat a path to your door. How will you stimulate them to give you the benefit of their knowledge? How will you develop standing if your recognition is confined to engineers within your company? How can your employer, in fact, know that in your mind and in your black book he owns an exclusive edge over competition? Over and over we have seen an engineer's mind open when he has tested his knowledge before his peers. He has found that others in his profession already had much of his "exclusive" knowledge. Those who had progressed beyond him were willing to contribute ideas and information that expanded his mental view and amplified his fund of knowledge. His mind continually gathered more than his black book could contain.

Happily, the black book attitude is waning. Users and makers of control have awakened to the benefits of exchanging knowledge. In fact some are now stimulating exchange with author incentive programs. Convair Div. of General Dynamics started such a program four years ago. General Precision, Inc. and its four divisions—GPL,Kearfott, Link, and Librascope—have just announced the latest one. It features two requisites to the long term success of an author incentive program:

- a clear statement that presenting and publishing engineering contributions is part of an engineer's job
- a means of screening the quality of manuscripts.

General Precision, Inc. states that the program will "encourage the technical advancement of employees in knowledge and ability, and it will create a favorable corporate image." One can't ask for more to burst the covers off the little black books.

W. E. Vannah

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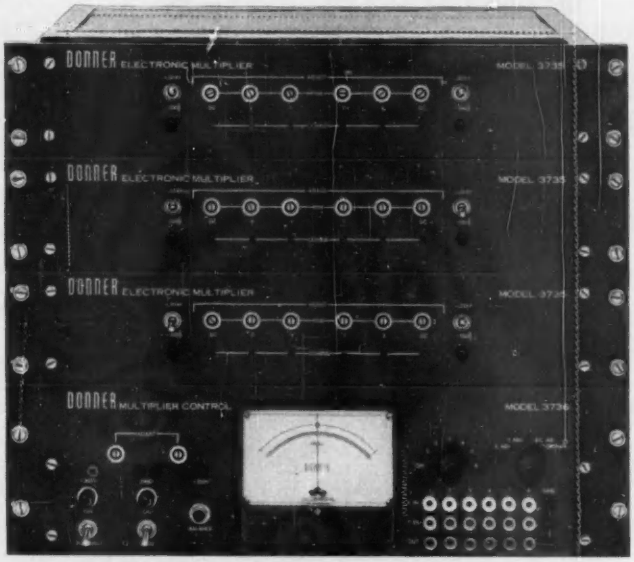

Illustrating three of the Donner Model 3735 Dual Electronic Multipliers (6 channels) associated with one Model 3736 Multiplier Control. This equipment provides 6 independent precision multiplier/divider channels, completely self-contained in only 15¾ inches of panel height.

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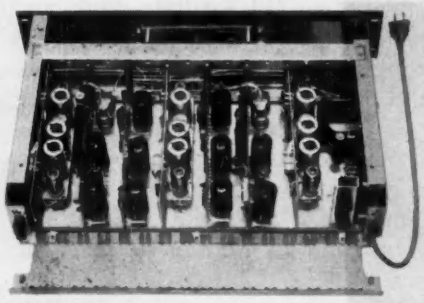

The use of plug-in printed circuit cards in the Model 3735 Dual Multiplier assures adequate ventilation and easy access to all components. Shows 2 channel unit. Available in 2, 4, or 6 channels.

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Safe, Reliable Process Monitoring
Part I: WHAT'S NEEDED

THE GIST: Regardless of the process under consideration, safe, reliable monitoring depends on the reliability of the transducers, the reliability of the way in which they are used, and the reliability of the monitoring system itself. Importance of the first two is only briefly mentioned here; the subject of this article is monitoring systems. The process used to illustrate this discussion, the Hanford reactor, is far from common. Its reliability and safety requirements, however, are very much like those of other critical processes. Of the two basic system types described here, the data sampling type appears to have far more to offer than the currently used continuous type.

R. SHERRARD, General Electric Co.

Just how reliable and safe a monitoring system must be depends on the process being monitored. But the same reliability and fail-safe criteria apply in each case. The following discusses these two requirements and the principle types of monitoring systems used to satisfy them.

Broadly classed, monitoring systems are either of the continuous or data sampling types. Main difference between the two is the way in which they handle transducer outputs. The continuous-type system uses complete alarm and indication circuits for every transducer output and monitors each signal on a continuous basis. The data sampling type of system, however, uses high-speed scanners and a single information channel to handle all transducer outputs. Relative to any particular transducer it is essentially a discontinuous system. Its advantages will be described in more detail later.

The process used to illustrate the problems in the following discussion is somewhat unusual. It is a Hanford reactor, a process in which uranium fuel elements are irradiated within process tubes to produce plutonium. There are several thousand such tubes, and the temperature and flow of coolant in each must be monitored with an extreme degree of reliability and safety. Safety here demands protection not only of the fuel elements but of the reactor itself. Full or partial loss of coolant or loss of adequate monitoring would be considered unsafe.

Reliability

In discussing reliability, three distinct probabilities must be considered:

1. the probability of detecting an unsafe condition and shutting down the process,
2. the probability of not detecting an unsafe condition when it exists because of a malfunction in the monitoring equipment, and
3. the probability of a monitoring system fault causing a false shutdown.

Items 2 and 3 are of a complementary nature. To insure the highest degree of success of item 1 and to minimize the probability of not detecting an unsafe condition (item 2), system configurations must be made inherently fail safe. This accentuates the probability of false shutdowns (item 3).

The success of item 1 depends on transducer reliability, reliability of the measurement techniques, and monitoring equipment reliability.

The best way to explain the meaning of measurement technique reliability is by example. Figure 1 shows a single process tube with temperature and flow transducers appropriately placed. In a venturi flow system where differential pressure is used as a measure of flow, it is apparent that the same flow in either direction can produce about the same pressure drop. Thus in any system where flow can be in either direction but process safety requires it to be in one particular direction, the measurement technique is unusable unless the pressure transducer is fast enough to trip during the transient period caused by the reversal of flow.

Reliability of the temperature measuring technique is also questionable. Referring again to Figure 1, it can be seen that a process piping break upstream of the temperature probe can cause the flow to reverse relative to the temperature probe. Under these conditions the probe would be monitoring outlet collector water temperature instead of tube coolant water. In a pressurized system a plumb-

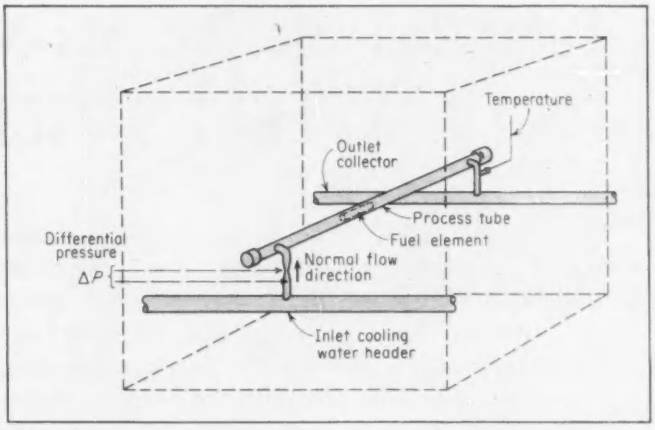


FIG. 1.
Single process tube with flow and temperature transducers located at either end.

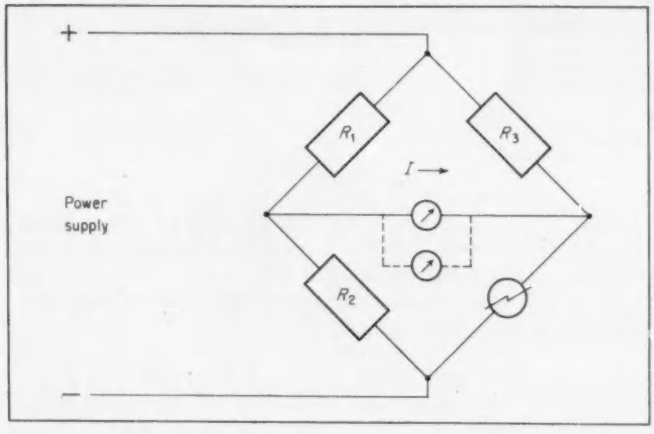


FIG. 2.
Simple bridge circuit illustrates the difficulty in providing absolutely fail-safe operation.

ing failure downstream from the temperature detector can also affect reliability of the temperature measurement if the coolant flashes to steam. Then the temperature of the steam-water mixture would be essentially constant for any given pressure. These examples illustrate some of the unusual variables that must be taken into account when analyzing the reliability of monitoring systems.

"Fail-Safe"

The highest degree of monitoring reliability requires that the monitoring system be capable of detecting its own failures, and in continuous systems the easiest way to indicate a functional failure is by means of a fail-safe trip. Any component or circuit will be termed fail-safe if its failure results in either a gross calibration shift in the safe direction, or the same system operation that would occur if the monitored point actually exceeded its limits.

The dilemma

In a continuous monitoring system it is almost impossible to avoid a certain number of safe, but false, trips. Of course there are some continuous system configurations in which equipment failures can be detected and announced. A number of these, however, have been evaluated and abandoned because of the complexity and cost of the necessary added equipment. Obviously, a totally fail-safe monitoring system with basically poor component and circuit reliability would produce continuous shutdown rather than a safe planned continuous operation. Conversely, it is just as evident that lack of fail-safe operation of a basically poor monitoring system could produce a continuous unsafe operation of the process. No complete solution exists for this dilemma; a much better approach would be to use a different type of monitoring system in place of the continuous system and to add logic that could distinguish between true out-of-limit process conditions and monitoring system failures. Techniques are available in data sampling systems that can fulfill the necessary requirements to a greater extent without requiring completely fail-safe operation.

No perfect solution

The simple Wheatstone bridge configuration shown in Figure 2 best illustrates the fail-safe re-

quirements and the degree to which they can be implemented.

Bridge parameters are chosen so that as long as process temperature (probe resistance) is safe, current flow in the detector circuit is in the direction shown. The detector, e.g. a polarized sensitive relay, is designed so that it is held open by the current flowing in the bridge and biased by springs so that it will drop out or close before the current balances in the bridge detector circuit. Reverse current will aid the spring closure. The circuit, therefore, fails safe for an open in the detector or detector circuit and for a power supply failure, provided the relay does not stick. It also fails safe for an open temperature probe but not for a short in the probe. If R_1 opens, the current reverses and the circuit is fail-safe; if it shorts, the failure cannot be detected and a gross calibration shift occurs. Open-circuit failure of R_2 also causes a gross calibration shift. If R_2 shorts, the circuit fails safe. A short in R_3 results in a fail-safe operation; open circuit failure of R_3 is not detectable and results in a gross calibration shift.

It is evident that not even a simple bridge circuit can be made completely safe without adding complexity. The best approach is to make the probability of component failure as remote as possible. While this can be done with components, circuits and solder joints require at least parallel redundant wiring and frequent test and inspection.

System Types

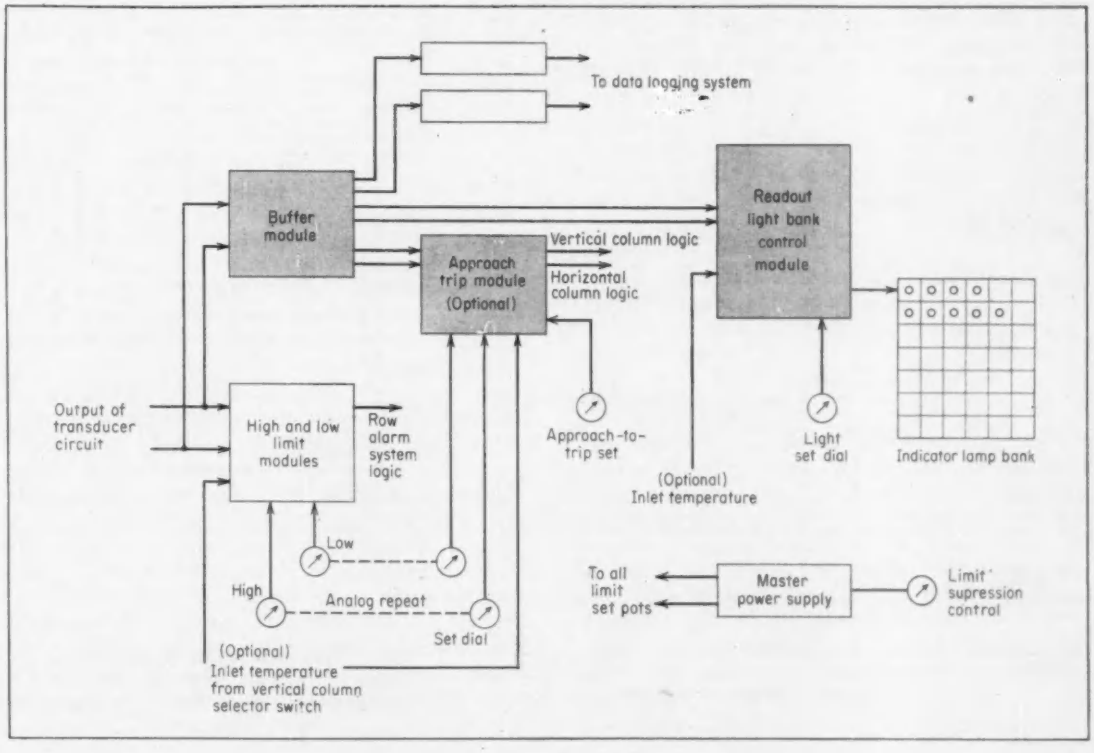
Of the several system types now available for process monitoring, the oldest and most used to date is the continuous type. When the number of points to be monitored becomes large enough, however, the newer high speed data sampling type of systems can provide a much higher potential over-all reliability at a cost equal to or lower than that of continuous systems.

Hybrid systems also exist in which a continuous monitoring function produces pulse-type information that can be handled by logic techniques similar to those used by data sampling systems. This type of system, however, is limited to a small number of functions since each must share the transducer, and cost of the input functional modules is multiplied linearly by the number of functions.

Continuous

A continuous monitoring system is illustrated by the block diagram of Figure 3. This could be either a flow or temperature monitoring system. Shaded blocks represent secondary functions used mainly to

FIG. 3. Elements of a continuous-type process monitoring system.



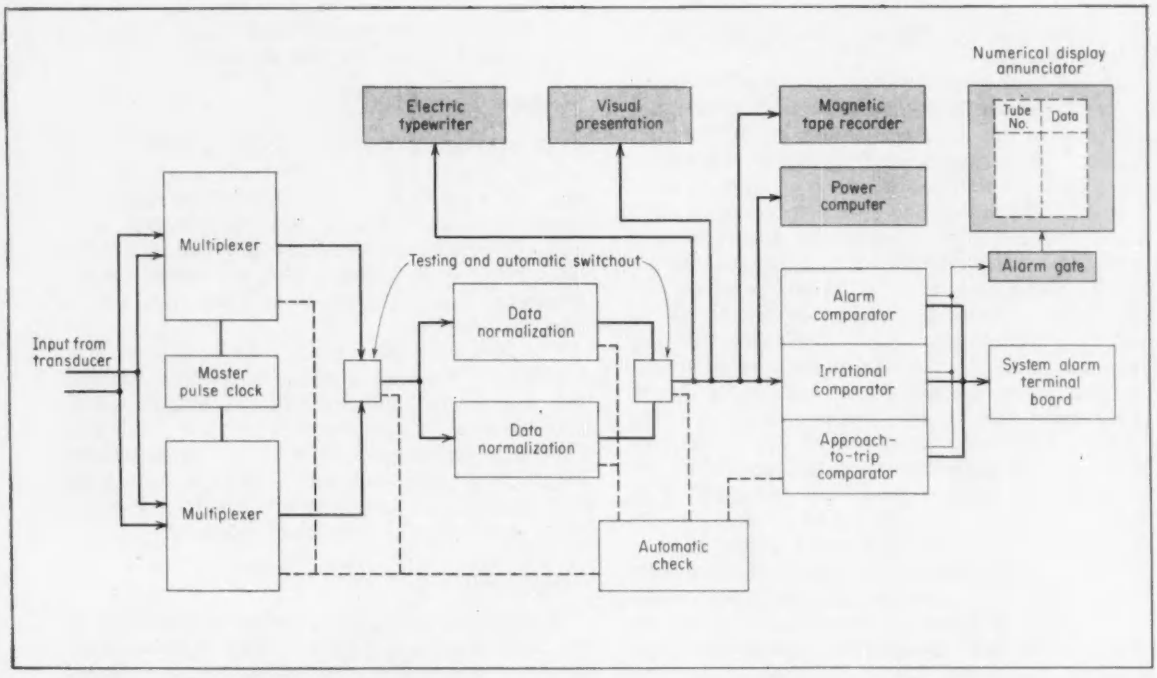


FIG. 4. Data acquisition-type monitoring system is single-channel beyond the high speed multiplexers.

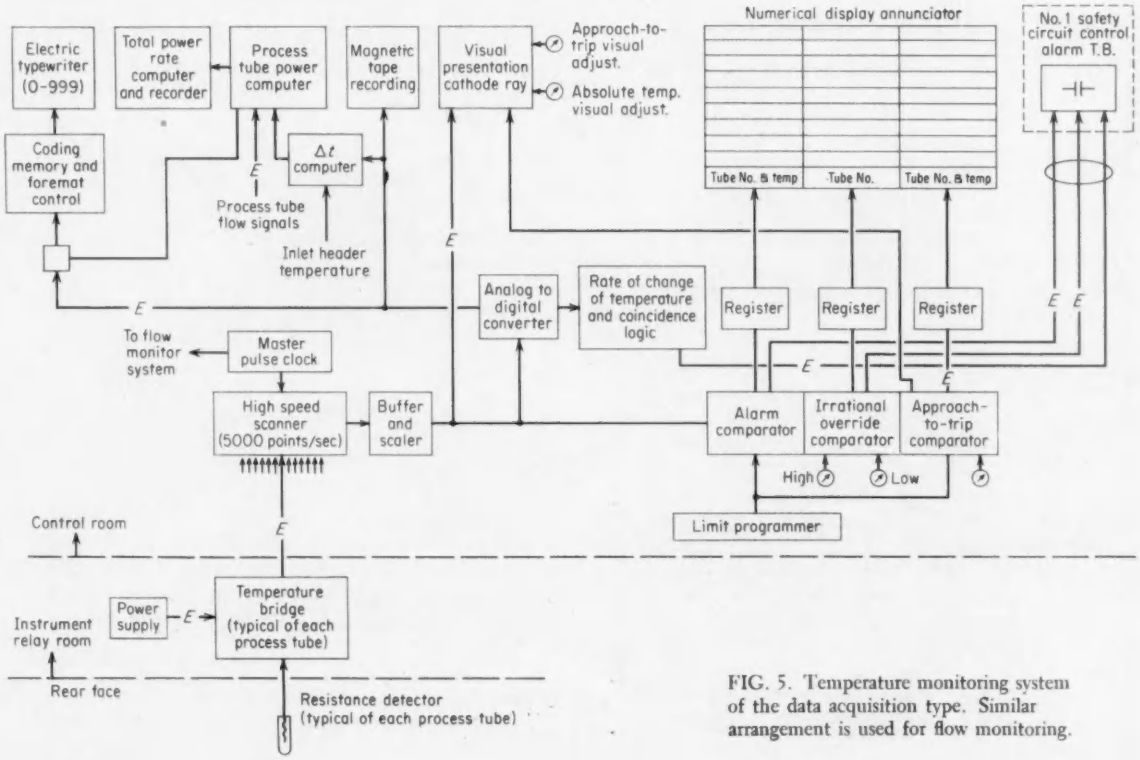


FIG. 5. Temperature monitoring system of the data acquisition type. Similar arrangement is used for flow monitoring.

guide the operator in controlling the process.

Functions generally required or desired in this type of system include: high or high and low limit monitoring, approach-to-trip (desirable but usually optional), readout of each measurement relative to a master setpoint dial (desirable as operator information in temperature systems but optional in flow systems), and buffered output for slow speed data logging of each point monitored.

The buffer module between primary and secondary functions protects the primary function from the effects of catastrophic failure of the secondary functions. Normally other functions would be desirable in a continuous monitoring system, but the added cost and effect on reliability rule them out.

Data sampling

Figures 4 and 5 illustrate functional arrangements of a high speed, data sampling-type monitoring system. From these it is apparent that several functions have been added primarily because they are needed and can be provided at a very low additional cost. As can be seen in Figure 4, the only part of the system that is full scale is the multiplexer. Functions of the system are obtained by just one redundant series channel of functional equipment. Because of the single-channel aspects of equipment beyond the multiplexer, a redundant functional block for each function contributing to the primary function is both feasible and required. With the speeds available (5,000 points per sec), the system can pause between data frames and program-in known calibration signals that can be used to check out all functional blocks and switch out those that indicate marginal performance or failure. Redundant blocks switched out will be indicated for manual replacement so that redundant spares are again available.

Figure 5, a more detailed diagram of the temperature monitoring system, illustrates the following primary system functions: high limit monitoring (the flow monitoring system would have both high and low limits), approach-to-trip monitoring to spot tubes in which trouble is just starting, and the monitoring and rejection of irrational data. ΔT monitoring to check temperature rise across the process can also be provided. Data normalization, an added function, supplies the proper process quantities for the secondary functions of data logging, tape recording, and numerical display.

Limits are set for each point monitored by selecting a number of programs and patching in a particular limit program for comparison with each point. The monitoring of ΔT is an added function readily available in this system but requiring extreme circuit modification for continuous-type use.

Approach-to-trip comparisons and irrational data comparisons are made against manually set master programs. Approach-to-trip manual controls can be used for example to locate the process point or points closest to trip; it can also serve as an early warning device during various phases of operation and can be arranged by permissive switching to cause an automatic power-cutback when one or more points approach the trip limit.

The irrational override or reject function, serves several purposes. Normally it detects system or transducer malfunctions and wiring failures and overrides trip signals if the values are beyond either a rational low or high limit. This irrational override feature is particularly useful in a coincidence trip-type system. It can be used in single transducer systems also but only under one condition: the possibility of a transducer or wiring failure occurring at the same time that an unsafe process condition exists must be extremely remote.

Visual display of process quantities equal to or greater than those set by manual control is a required secondary function and a valuable operating guide. Normally a CRT serves this purpose.

Because of the system's high scanning rate, the magnetic tape unit can be used not only to store data for subsequent computation but also to record actual process data during an emergency shutdown or scram.

By its nature the data sampling type of system will readily accommodate a computer that can be used to determine total power, power rate, and process yield. With the necessary programs facilities in the data normalization block, this type of system can be made to monitor almost any kind of electrical data.

Another fundamental difference between the continuous and data sampling systems is based on the manner in which a trip signal is used after detection of an out-of-limit process condition. The data acquisition system, being essentially one-channel, has but one normally energized output. Upon detection of a process alarm or scram condition, it simply deenergizes its single output and identifies the source of alarm on the display panel. The continuous system, unfortunately, is full scale all the way through, and a full scale system of alarm logic is required to inform the operator that an out-of-limit condition has been detected.

Working systems

The foregoing has shown what functions are required to assure the reliability and fail-safe operation of process reactor monitoring systems. The advantages of the data sampling type of system over the continuous type of system have also been noted. In the second half of this article actual operating experience with both the monitoring systems and the transducers will be discussed in detail.

Some previous reliability history will be reviewed and means will be suggested for specifying reliability requirements for future systems.

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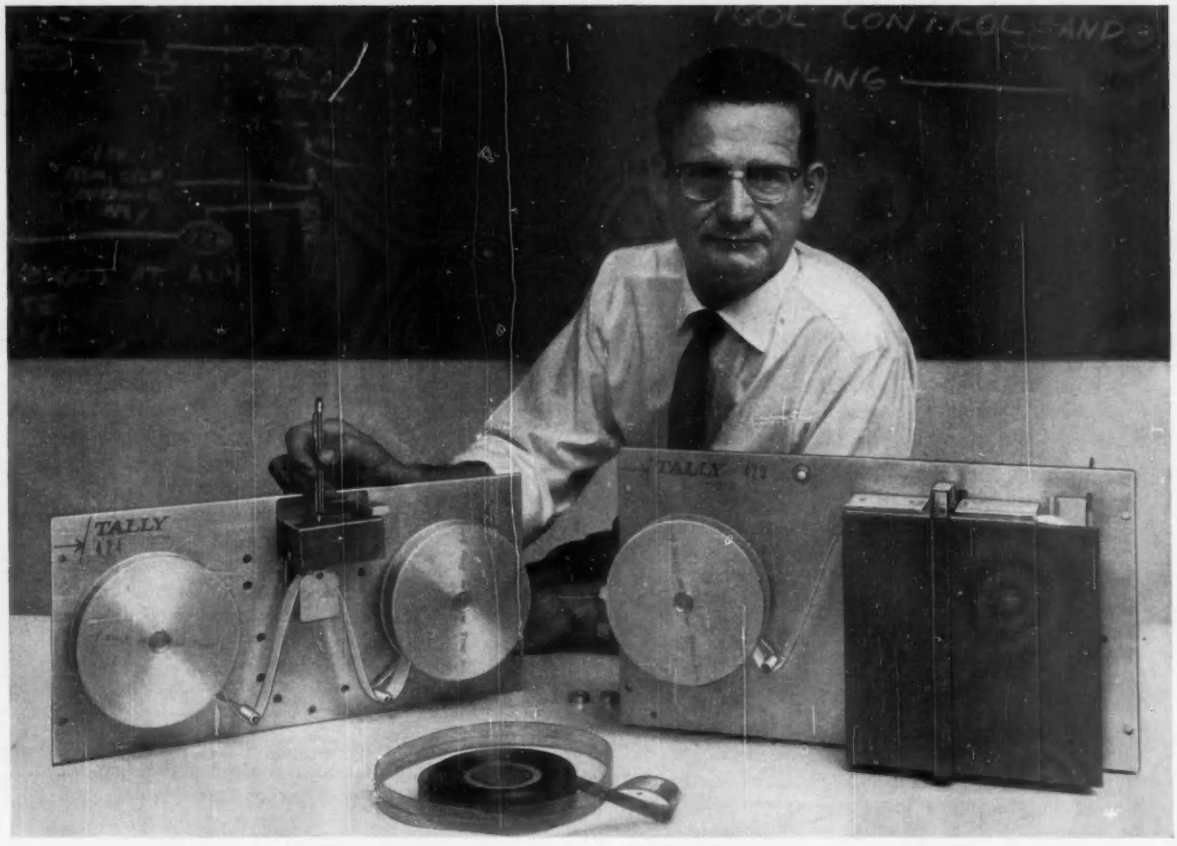

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Generalizing the Adaptive Principle

This is the final article in a three-part series describing the adaptive principle. In the first article, "Making Sense out of the Adaptive Principle" (August '60, pp. 113-119), author Gibson defined adaptive controls and discussed the three criteria required by the definition. In the second article "Designing and Mechanizing the Adaptive Principle" (October '60 pp. 109-114) the author described seven controls called adaptive.

GIST: The generalized adaptive control serves as an ideal for the designer to strive for but never reach. Studying the ideal adaptive system indicates one of the designer's severest problems: how to make the control search for the desired optimum. The author describes a method of "steep descent" to speed the searching process and discusses three possible improvements that can be made on the method.

J. E. GIBSON, Purdue University

One way to understand what the control engineer can expect from the adaptive principle is to study a generalized adaptive system, then to examine how this idealized approach can be modified technically and economically to produce a feasible system. The ultimate adaptive control would be completely generalized as shown in Figure 1. It satisfies three requirements, the most general that can be placed on the control system (Ref. 1):

1. The adaptive control must cope with a plant (H_1 and H_2 in Figure 1) whose transfer function is initially unknown. In addition, H_1 and H_2 are nonlinear and time variant.
2. The form of the equalizer which the adaptive control synthesizes is not restricted in advance to lag or lead or other conventional networks. The transfer function may consist of a ratio of polynomials, whose order and coefficients vary with application.
3. The measuring and computing process necessary to determine the values of the equalizer coefficients or modified signal will not in any way disturb the normal operation of the system.

The ideal control consists of a box labeled "computer" and the devices required for sensing the input and output signals. Such a system might be mechanized in a number of ways. The computer could be a special purpose digital machine with auxiliary data handling equipment and some physical equalization equipment (such as that described in Ref. 2) that would be adjusted by the computer. Or the equalization process could be accomplished internally in the computer, with connections to the system through input and output equipment. This configuration can be generalized into multiloop systems, to be time-shared by a general purpose digital computer. Or a special purpose analog computer can be designed to fit this control system. But the functions of binary logic and storage seem more natural to a digital device, so the digital computer is a more obvious choice.

Although none of the systems discussed in Parts I and II of this series meet all the criteria of an adaptive system—in fact it does not appear economically feasible to construct a control capable of such complex adaptation—these criteria have a purpose: they indicate some things *not to do*.

For example, the first requirement prevents the designer from selecting as an optimization criteria some special attribute in the response of a particular system. Thus it would be improper to measure "time to first zero of error", for example, for a step

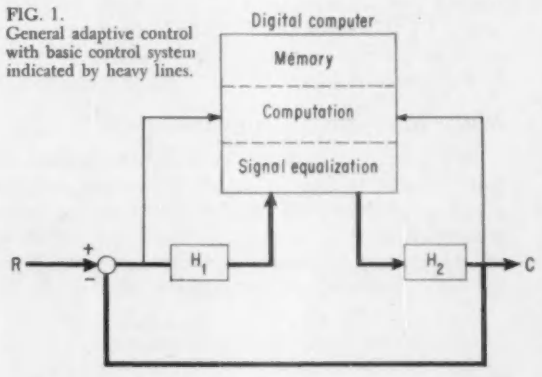
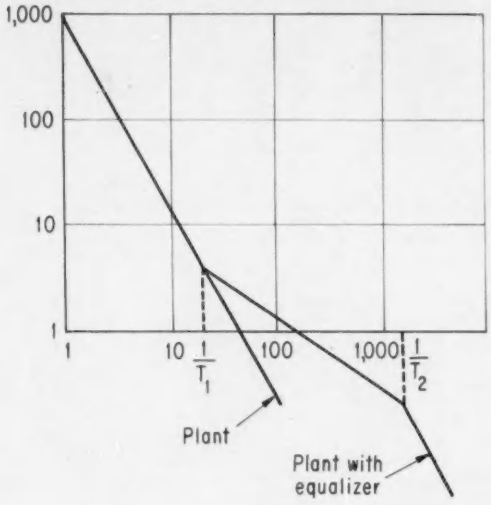


FIG. 1. General adaptive control with basic control system indicated by heavy lines.

SPECIAL CASE OF THE IDEAL ADAPTIVE CONTROL

FIG. 2. B—Bode diagram shows that system stability can be improved only by a lead network, not a lag. T_1 and T_2 are the time constants of the equalizer to be adjusted by the adaptive control.



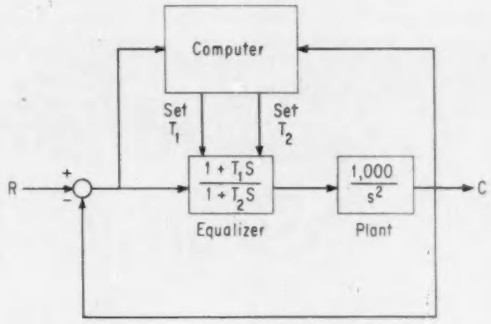


FIG. 2. A—Simple control for multidimensional optimization.

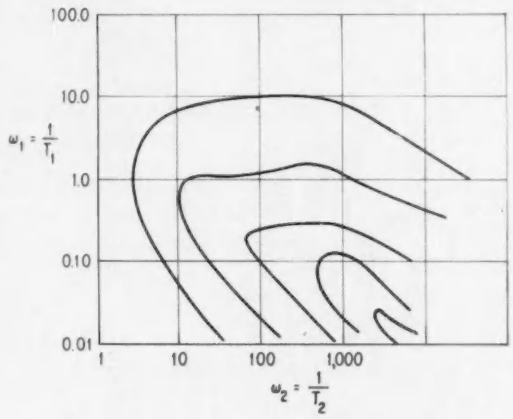


FIG. 3. Given values of the figure of merit are connected together to form contours or lines of constant figure of merit. The adjustable control would try to push the control until it had infinite bandwidth and zero response.

function input because a poor system might look like a good system by this simple measure.

The second requirement bars simply adjusting the gain of values of a lead network, for example, to obtain optimum response. The reason: one of the main purposes of installing an adaptive control is to obviate determining the transfer function of the plant prior to installing the control, either to save time and money or because it is impossible to make this determination. Without such knowledge, of course, it is impossible to know in advance what kind of equalizer would be desirable.

And the third criterion prevents the designer from interrupting the normal operation of the system to measure its response by a special input. The objection: a disturbance might be intolerable to the system. In the autopilot of a high performance aircraft, such input might put the plane out of control; in a chemical process, it might spoil the product.

Multidimensional adaptive control

In Figure 2A is a simple generalized adaptive control. It will become unstable if the adaptive loop acts incorrectly; it will have to adjust several parameters to achieve an optimum. To this it will adjust the parameters of a series equalizer. T_1 and T_2 are the time constants of the position of a single zero and single pole whose values may be adjusted.

In this case the equalizer is a special case of the general lumped parameter form—a ratio of polynomials in power of s. By sketching the root locus or Bode diagram (Figure 2B), the designer discovers that system stability can be improved only by a lead network, not a lag. This fact also emerges from the adaptive loop operation so it is not necessary for him to know this in advance.

If minimum ITAE (Integrated Product of Time and Absolute Error) is chosen as the optimizing criterion or figure of merit for this example, it can be calculated for various values of T_1 and T_2 and the results plotted for constant figure of merit (Figure 3). The contours apparently do not close in the finite region; the sides of the valley are quite steep on three sides, but the floor continues to slope downwards. Such a condition might not be anticipated by a designer conditioned to working with a conventional equalizer; in the absence of directions to the contrary, the adaptive control will push the equalizer until it yields a system with infinite bandwidth and zero response time.

Although this example is a special case, the possibility indicates that the adaptive control requires some careful restraints. In higher order systems the contours will usually close in the finite region,

but open contours occur more often than expected. The most usual restraint is to constrain the equalizer within certain maximum and minimum limits.

Another situation that requires constraint is the case of the control system with the false minimum, supplying curves of constant figure of merit like those in Figure 4. If the adaptive control locates the false minimum first, it will stay there. No simple automatic procedure has been developed to prevent this; it occurs, however, only in complex systems of rather high order.

The method of steep descent

Unfortunately such contour drawings are not normally available: they would be expensive in machine time and cost to calculate, and they would require previous knowledge concerning the supposed location of the minimum to assign an area to search. What is needed is a method of intelligent search or steep descent to the minimum (Ref. 3).

One relatively simple approach has the following procedure (Figure 5):

a) Arbitrarily choose a point (point a, Figure 5) somewhere in the T_1:T_2 matrix and calculate the ITAE or given figure of merit.

b) Calculate the ITAE for the next larger and next smaller values in the T_1 direction and in the T_2 direction (points b_1, b_2, b_3, b_4), thus producing four more ITAE values.

c) Calculate the change in ITAE from the arbitrarily chosen point to each of the four additional points; then consider that point showing the greatest decrease as a new center point, adjusting to it.

d) From the new center point, again calculate surrounding points in the T_1 and T_2 directions, producing three new data points.

e) Again choose that point showing the greatest decrease as a new center point and continue.

This procedure has at least three advantages: it can be used for any number of coordinates, it does not depend on initial knowledge of the location of the minimum, and it will continue to track the minimum even if it changes its location with a change in parameters—the essence of adaptive control.

At least three variations have been suggested to improve this method of deep descent. First, if the size of the increment is chosen so it is a function of the rate of decrease, when the rate of decrease is large, the increments will be large; and when the optimum is approached, the steps are small. This combines economical search away from the minimum with accurate adjustment near it. Both the Quarie Controller and Opcon (described in Part II) have some form of increment adjustment.

Second, if new points are selected on "the diagonal" instead of at 90 deg with the arbitrary point (see Figure 5, refined method), the procedure can be shortened. The new point (c in Figure 5), a better choice, has not been measured, but it can be located by a calculation of vector descent.

Third, if some memory is incorporated into the procedure, an initial choice of the most likely direction of descent is made and calculations are made only in this direction as long as the results yield descent. Dimensional searches are made when a move in the expected direction does not yield it.

These methods are primitive relatives of the methods of "steepest descent" used by mathematicians to solve complex problems in variational calculus. Such complex techniques are likely to be useful in control if the adaptive controller is a general purpose digital computer. The exact balance between complexity of approach versus practical reliable system performance is likely to be the subject of study in adaptive control for some time.

Since the method of search is an important aspect of the operation of adaptive control systems, considerable research is being expended to improve current methods and to conceive new ones. The presence of noise in the system or ambiguity in the measurement of the system response determines to some extent the method finally selected. For example, in a system whose noise level is low, the designer can make predictions about the location of the optimum—thus permitting large movements toward the optimum—but he cannot make these estimates if the system is noisy.

These theoretical methods of searching have a counterpart in actual systems. In the complex multidimensional adaptive system, the controller has to track the optimum in a systematic way. If three or more dimensions have to be searched, time prohibits a random search. The search effort can be divided into two parts: learning time and slewing time. The former is the time the adaptive control requires to decide in which direction to move; the latter is the time required to execute the movement once a direction decision has been made. One bit of research is aimed at telescoping these two operations to speed up the system. It may be possible to start slewing after the control has a rough indication of the direction to pursue, instead of waiting for the completion of the learning process.

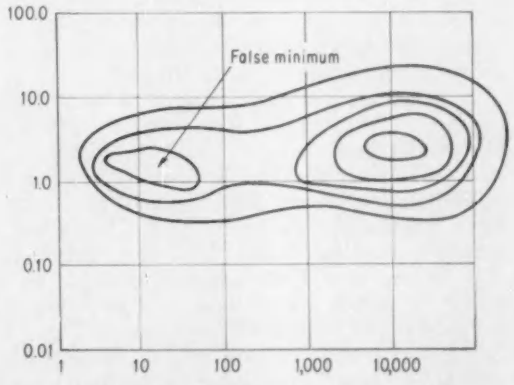
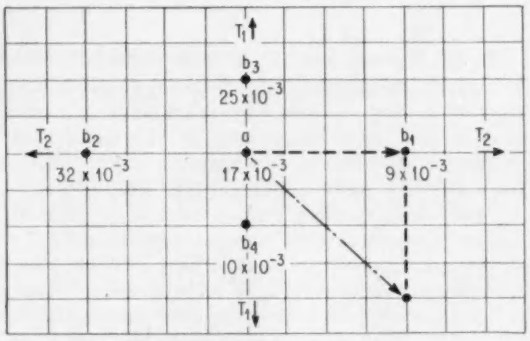


FIG. 4. False minimum may develop in complex higher order systems when figure of merit is plotted.



a = arbitrarily chosen point
b_1 to b_4 = points of increasing and decreasing T_1 and T_2
Numbers are values of ITAE
– – – – – Simplified method
—·—·— Refined method

FIG. 5.
Method of steep descent

The stability problem

Another serious problem in complex, high performance adaptive systems is stability. Intuitively a designer feels that reducing the increment of search as the optimum is approached will exert a stabilizing influence on the adaptive loop. The reverse of this same condition, however, does not guarantee stability. When the increment automatically increases to follow a rapid drift of system parameters and if the gain of the adaptive loop is made as high as possible to help the rapid followup, then stability is not obvious. Many adaptive system designs try to avoid this problem by making the adaptive loop slow and sluggish. But this is only a temporary solution. If a user finds an adaptive control desirable for an application, eventually he would want that control to be capable of high performance.

The future for the adaptive principle

How far and how fast application of the adaptive principle goes depends on a number of factors which might be considered in the form of five questions, some of which already have been discussed:

1) **What are the advantages of the adaptive principle?** It allows the automatic control of a process or system whose parameters undergo wide changes of value in an unpredictable manner. It may also control systems whose dynamics initially are partially or completely unknown to the designer.

2) **What are the disadvantages of the adaptive principle?** In its general form adaptive control will be complex and expensive. And the adaptive control can be no better than the figure of merit chosen by the designer to represent optimum performance. Good engineering can help reduce the effect of these disadvantages in any particular application.

3) **Where should the adaptive principle be applied?** It should not be thought of as a substitute for good engineering; it will not work miracles. Unless parameter variations are wide and unpredictable or it is impossible to measure the transfer function of the system, adaptive control should not be used.

It is important that the variation of parameters should be wide and unpredictable. If by measuring some environmental quantity it is possible to predict the variation of a system parameter, an open-loop method of compensating this parameter will probably be simpler and cheaper. If several factors interact on several parameters, adaptive control may be simpler even in systems with predictable variations.

4) **Should a general adaptive control be employed?** Probably not. All of the designer's knowledge of the system should be employed so that the minimum effort is left to the adaptive control. The general adaptive control described above serves mainly as a philosophical model and may never be built. In fact, there is one school of thought that believes a portable adaptive control should be used, but only until enough knowledge of the process is gained to design a simpler, conventional control.

5) **What about future applications?** As control problems become more and more complex, a designer has more difficulty tracing through the system to establish the effect of every conceivable disturbance and parameter change. Obviously the system will be improved if it is able to sense these changes and correct itself. Thus for complex problems the expense of adaptive control will be warranted.

Many hitherto uncontrollable processes will be tamed: for example, a production process in which the optimum rate of operation depends upon such things as 1) increased rate of wear on machinery as speeds are increased, 2) existing inventory of the final product, 3) weather conditions and seasonal effects that influence the use of the product, 4) economic conditions that influence the use of the product, 5) the profit available if the machines were turned to produce another product entirely, and 6) the effect on worker moral of speedups or periodic shutdowns.

Probably one of the biggest uses of the adaptive principle will be to shorten the lead time required to develop new controls for new systems. Complex adaptive controls can be applied initially on the process to establish the boundaries and limits of operation. Then a conventional control or a simplified adaptive system can be substituted when enough is known. Thus, in effect, the adaptive system is taking over what conventionally would be part of the designer's job.

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Incremental Servos
Part II: Operation and Analysis

THE GIST: As pointed out in Part I of this series, all stepping motors can be broadly classed as either solenoid-ratchet or phase-pulsed synchronous devices. This article discusses the operation of each of these two classes, using a single example in each case. The author then goes on to take a quick look at the importance of inertial load matching and concludes with an interesting review of the analytical nature of stepping controls—how they resemble, and differ from, the more conventional servo types.

S. J. BAILEY, Vitro Corp. of America

In the first part of this series (November 1960) stepping motors were classified in a number of ways. By far the most significant of these is the general classification based on operation. According to this division, steppers are either solenoid-ratchet devices or phase-pulsed synchronous devices. Although each type is well represented by commercially available models, only two will be described here. Only in their broadest design concepts can these examples be called "representative" of their types. Primarily they were selected because of their interesting design features and because they serve to illustrate the greater differences between the two types.

Solenoid-Ratchet type

Figure 1A shows a simple stepping device with electromagnetically preloaded actuating springs. Stepping is accomplished by spring force released through power shutoff. The critical elements are the dynamic ones: armature, armature hinge, bearing, contacts, ratchet wheels, pawl and detent.

Mechanical detenting is chosen because it provides positive, accurate steps and prevents wandering at the indexed position. The detent spring at the top aids the armature spring action in the final stages of deceleration, while preventing overshoot. Armature motion is kept at a minimum, thus using optimum solenoid force. Armature hinge and bearings are carefully designed for minimum friction. Contact A has the requisite built-in delay without resorting to friction or other unreliable methods. The actuating ratchet wheel, a straightforward design, is supplemented by a similar device for actuating contact B. Contacts A and B operate in series to energize the solenoid. At any indexed position, these contacts are both closed, so that a single current pulse actuates the device for a single step. With a constant current applied, the device will continue to step. Contact A opens when the armature approaches its travel limit. Contact B opens when the spring stroke starts, keeping solenoid deenergized during stepping.

Figure 1B illustrates the operation. At (1) the electromagnetic force has become sufficient to move the armature against the actuating spring complex. At (2) secondary elements of the spring complex are encountered under conditions of high armature acceleration and force. Note the drop in velocity. Slightly before travel, contact A deenergizes the solenoid. The armature continues to travel to its limit stop (4), remains there until, at (5), the loaded spring begins to discharge its stored energy. At (6) the pawl energizes the ratchet wheel and shortly thereafter contact B opens. Contact A may now close without causing the solenoid to energize, so that the stroke may be properly completed. By (9) the detent has passed the "peak" so that the detent spring can now aid the armature spring complex. At the final position (10) contact B closes, and the electrical circuit is ready to repeat the cycle.

This particular stepping device is primarily actuated by a 28-volt, 1-amp pulse of 10-15 millisec duration. The pulse may be derived from a control system power source or an associated transistor trigger.

Some of the modes of operation, for a current pulse input, are shown in Figure 2. For clarity, the stepping mechanism is simplified to actuating and detenting essentials. Figure 2A shows the basic stepper, while Figure 2B shows the basic unit plus an integral potentiometer. Synchros, resolvers, or other electromechanical components may be added as desired. In Figure 2C a commutator assembly

SOLENOID-RATCHET STEPPER

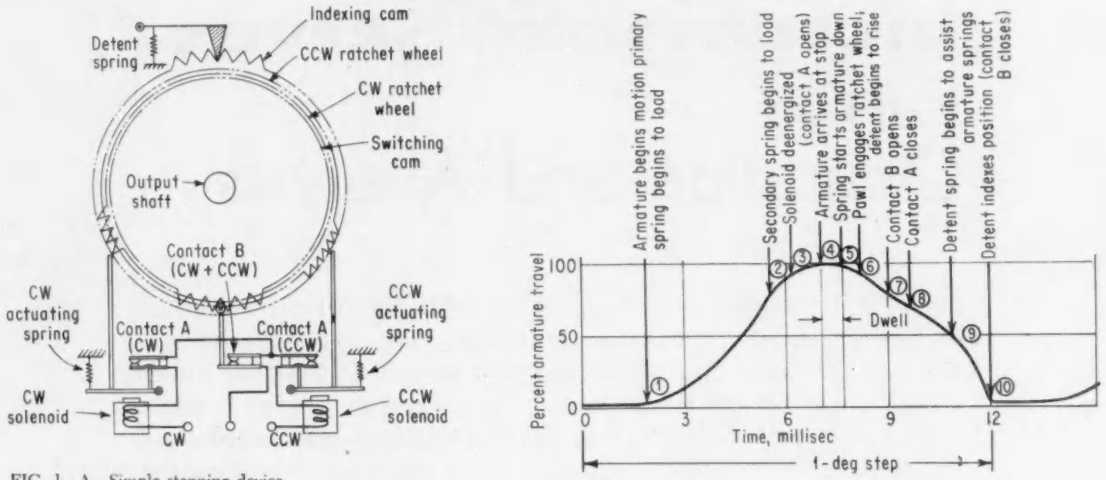


FIG. 1. A—Simple stepping device, typical of the solenoid-ratchet type and B—its armature travel during a single step of its output shaft.

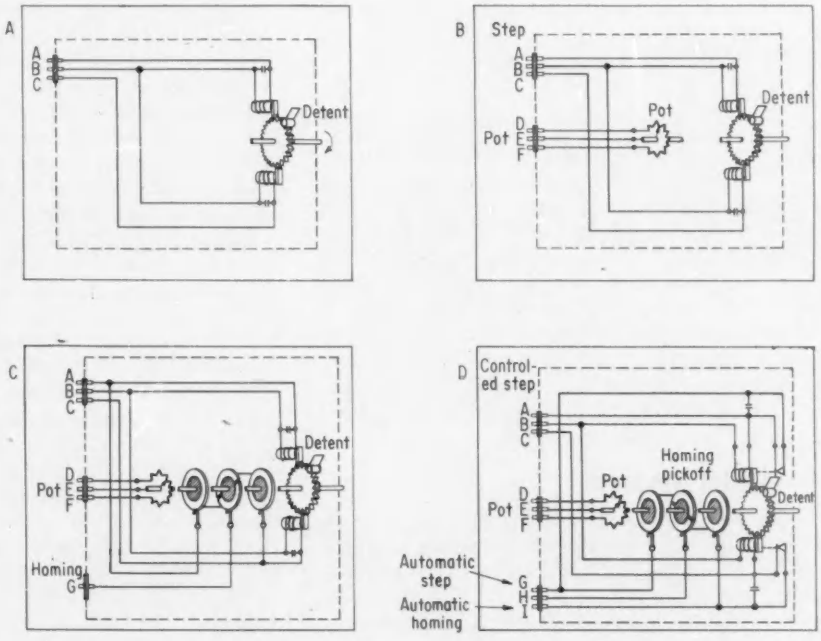


FIG. 2. Simplified schematics showing typical operating modes of a singlestepping motor.

provides for returning the output shaft to a previously indexed (home) position by an input at the homing terminal. In Figure 2D the operation has been expanded to include controlled and automatic stepping as well as automatic homing. Here the term "automatic" means continuous stepping or homing with a fixed input voltage.

Phase-pulsed synchronous type

The next design example is a phase-pulsed synchronous motor. One is shown in Figure 3.

In this type of motor only two phases (designated "plus" and "minus") are switched alternately to the winding. The device is similar to a three-phase synchronous motor except that one of its stator windings is replaced by a permanent magnet field which provides "no-current" stopping and holding torque.* The rotor has no windings, hence no slip rings. It can be made bidirectional by stacking two units. The stator has two salient pole groups X and Y. These are spaced so that when one group aligns with rotor

* *Protected by U. S. Patent No.* 2,834,896

teeth, the other group aligns with spaces between the rotor teeth. Thus, there are 20 positions, 18 deg apart, on one revolution of the rotor when its teeth will be in alignment with one set of stator teeth.

A third soft iron stator structure carries six rather sharp teeth at 18-deg intervals so that for each step of the rotor, three of them will align with rotor teeth. This structure Z is connected by two permanent magnets to each of the other salient pole groups. The magnets are in parallel, sending flux through this third stator element to the rotor. There it divides and returns to the magnets via extensions of the other two stator parts, X and Y. In this device stator element Z is referred to as the detent pole; elements X and Y, as the driving poles. The detent pole is about 6 deg around from a position where rotor teeth can be in alignment both with it and with a driving pole at the same time. Thus the rotor always comes to a position about 4½ deg away from alignment with the nearest driving pole (Figures 3A and 3C). The operating sequence in Figure 3 is schematically the same as that of a polarized relay.

The permanent magnet performs two basic functions: 1) it permits coil current polarity to determine where torque shall next be produced, and 2) it provides torque to advance and hold the rotor (when no current is provided) in a position favorable for further coil current influence. Figure 4 shows rotor torque for all combinations of positions and maximum effective current.

Figure 5 shows typical input circuits applicable to the two-phase pulsed motor. These diagrams include a center-tapped battery drive, a vacuum tube drive, and a transistor drive. The phase-pulsed synchronous motor can also be operated as a synchronous motor, making it useful for dual mode operations of "slewing and inching".

In general, the main advantages claimed for the phase-pulsed synchronous type of stepper include fewer moving parts, longer life, and faster response.

Load matching

Driven elements are somewhat critical in stepping motor applications since a given load must be accelerated to a peak angular rate and decelerated to zero angular rate during each unit step cycle. If, for ex-

PHASE-PULSED SYNCHRONOUS STEPPER

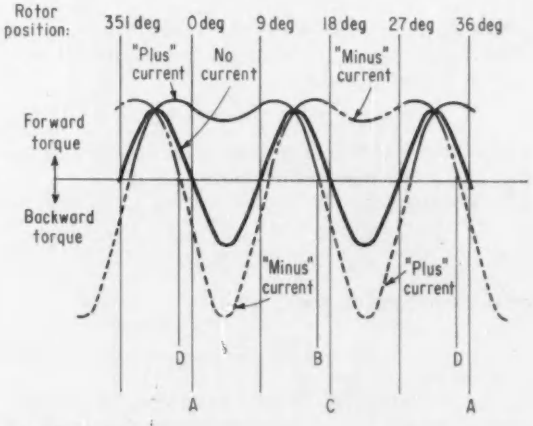
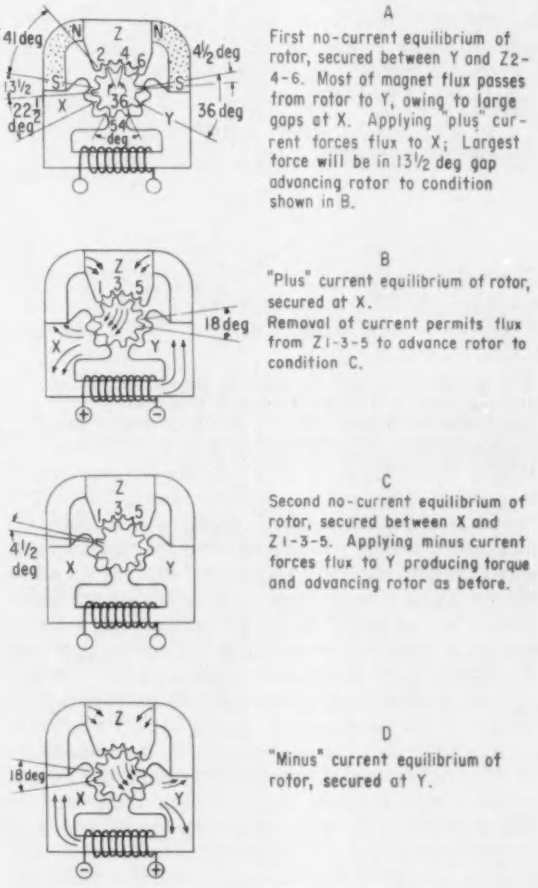


FIG. 4. Rotor torque and position diagram.



A
First no-current equilibrium of rotor, secured between Y and Z2-4-6. Most of magnet flux passes from rotor to Y, owing to large gaps at X. Applying "plus" current forces flux to X; Largest force will be in 13½ deg gap advancing rotor to condition shown in B.

B
"Plus" current equilibrium of rotor, secured at X. Removal of current permits flux from Z1-3-5 to advance rotor to condition C.

C
Second no-current equilibrium of rotor, secured between X and Z1-3-5. Applying minus current forces flux to Y producing torque and advancing rotor as before.

D
"Minus" current equilibrium of rotor, secured at Y.

FIG. 3. Sequence illustrates operation of a typical phase-pulsed synchronous stepping motor.

STEPPER DRIVE CIRCUITS

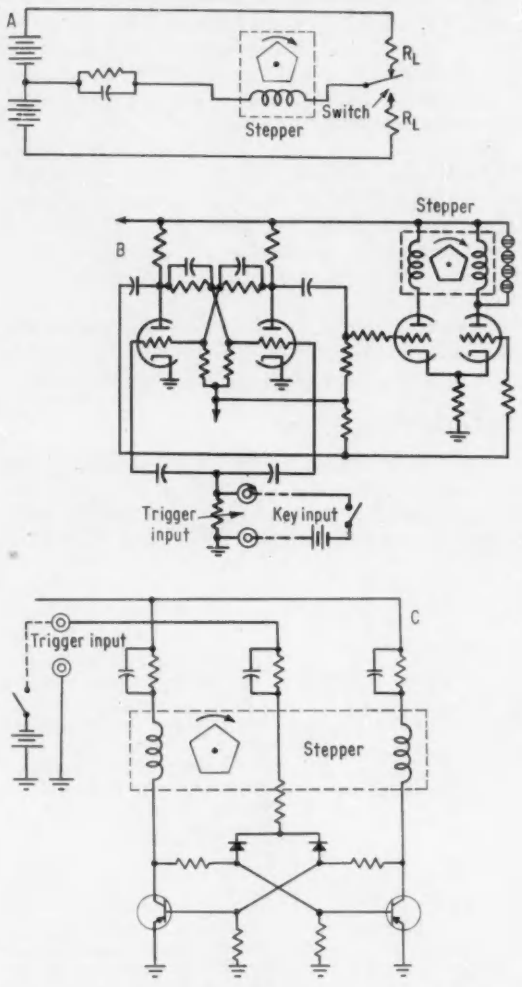


FIG. 5. Input circuits for use with the phase-pulsed type of stepping motor: A—simple center-tapped battery drive; B—vacuum tube designed for either a trigger or key input; C—Two-transistor drive circuit that takes an approximately constant input power for all output stepping rates.

ample, the pawl "bounces" against the ratchet, because of excessive forward acceleration, the stepping function will assume a chatter or, in extreme cases, an actual backward stepping. The above condition would be aggravated by a high inertial load with excessive angular momentum. Careful matching of load impedance is necessary and requires proper selection of spring and damping parameters in conjunction with the loss moment of inertia. Load control at step completion is usually simpler in mechanical detenting than it is in electromagnetic detenting which, without rigid indexing, requires some damping. In many phase-pulsed synchronous drives operating at very high stepping rates, there is no actual zero angular rate achieved between steps. The final position, however, still presents a damping problem, since the remaining energy associated with one step may either oppose a second step or aid it so that a third (spurious) step results.

Figure 6 shows graphically the extent to which inertial loads must be observed and compensated by adequate damping and spring coupling for various stepping rates. It should be noted that these curves are representative and do not necessarily apply universally.

Analytical approach

Before getting into typical stepping motor applications in the next part of this series, it might help to take a brief look at the analytical nature of these devices. This will reveal some interesting similarities between the characteristics of a stepping motor during a single step and those of more conventional position and velocity servos.

Unit step dynamics

The block diagram, Figure 7, illustrates the unit step behavior of any stepping motor. While it ideally represents the phase-pulsed synchronous type, it can in a broader sense also represent the solenoid ratchet type. Essentially it shows that as soon as a forward driving torque is applied, the motor begins to generate a reverse stopping torque. When net torque on the output member reaches zero (step termination), the output member should reach zero velocity. This can be written as follows:

$$K_1E(s) - K_2\theta(s) = 0 \qquad (1)$$

where $K_1E(s)$ is the forward torque, and $K_2\theta(s)$ is the reverse torque. Relating the two torque terms to motor dynamics yields:

$$K_1E(s) - K_2\theta(s) = [Js^2 + (f + f_d)s]\theta(s) \qquad (2)$$

where f represents viscous drag, f_d the adjusted damping, and J the moment of inertia.
The transfer function can be written as follows:

$$G(s) = \frac{\theta(s)}{E(s)} = \frac{K_1}{Js^2 + (f + f_d)s + K_2} \qquad (3)$$

or in more familiar terms as:

$$G(s) = \frac{K_M}{s^2 + 2\zeta\omega_o s + \omega_o^2} \qquad (3a)$$

The similarity to a Type II position servo is evident. Reverse torque is analogous to the feedback loop. This analogy applies regardless of the motor type or the way in which its reverse (stopping) torque is generated. In practical mechanisms, however, the reverse torque term will depart somewhat from linearity.

Obviously f_d and the other parameters must yield a damping ratio (ζ) which will cause the device to settle into a sufficiently quiescent state before the start of a new step cycle.

For a damped sinusoidal oscillation, which is actually what occurs as a stepping motor comes to rest

after a single step, the following inverse Laplace transform (Ref. 1) applies:

$$L^{-1}G(s) \cong L^{-1}\left[\frac{1}{(s+\alpha)^2+\beta^2}\right] = \frac{1}{\beta}\, e^{-\alpha t} \sin \beta t \qquad (4)$$

where α and β are related to the damping coefficient and natural frequency of the motor in the usual way. It appears from this that the relationship between α and the stepping frequency $1/T$ is very significant. Because $1/\alpha$ equals $2J/(f + f_d)$, the adjustment of f_d will be important in maintaining the value of $1/\alpha$ sufficiently smaller than T.

Analytical difference

From the foregoing it would appear that a conventional *position* servo is analytically similar to a stepper motor acting as an incremental servo. This cannot entirely be the case, however, since a unit impulse applied to each of the two devices will not elicit identical responses. The stepless servo will experience a disturbance and return to rest in accordance with its dynamic characteristics; the incremental servo will respond similarly, but come to rest at a *new position, one unit angle* from its start.

In this respect the incremental servo resembles the velocity servo whose generalized response to a unit impulse is:

$$\theta_o(s) = \frac{Kn}{s(s+\gamma)} \qquad (5)$$

Equation (5) states that after the disturbance has settled there remains a finite output. The equation can now be written for the stepper response with its built-in "metered" angular increament, θ_u:

$$R(s) = \theta_o(s) = \frac{\theta_u}{s}\,\frac{\omega_o^2}{s^2 + 2\zeta\omega_o + \omega_o^2} \qquad (6)$$

The pressure of ω_o^2 in the numerator points up the fact that the residue at s equals θ is exactly θ_u. It also indicates that the reverse torque of Figure 7 is exactly matched with the forward torque to yield the design angle each time a step is taken.

For properly adjusted load conditions Equation 6 becomes:

$$R(s) = \frac{\theta_u}{s}\, e^{-t_c s} \qquad (7)$$

where t_c is the time delay per step, and $e^{-t_c s}$ the transform of a time-shifted stop (transportation lag). In cases where motor response is relatively fast compared with the input data,

$$R(s) = \frac{\theta_u}{s} \qquad (8)$$

Since a unit impulse has a transform of unity, the transform of the stepping motor is also expressed under varying conditions by Equations 6, 7, and 8.

A series of unit impulses occurring at intervals of T seconds will produce a staircase output as shown in Figure 8:

$$R(s) = \frac{\theta_u e^{-t_c s}}{s(1 - e^{-ts})}, \qquad \text{where}$$

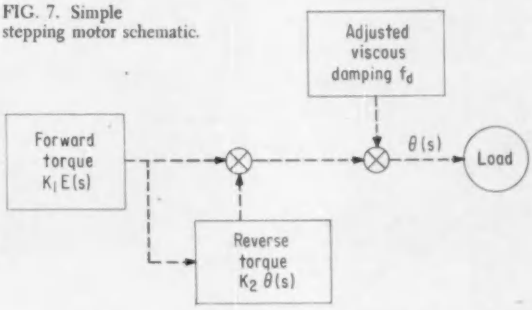
$$\frac{1}{s(1 - e^{-ts})} = \frac{1}{s}\left[1 + e^{-ts} + e^{-2ts} + e^{-3ts} \ldots\right] \qquad (9)$$

A finite number of impulses n with periodicity T would yield the s-transform response:

$$\theta_o(s) = \frac{\theta_u}{s} \sum e^{-(n-1)Ts} \qquad (10)$$

Equation 10 points up the stepper operational characteristic of finite summation. Under conditions of data periodicity $T_D >> T$, the stepper may be

FIG. 7. Simple stepping motor schematic.



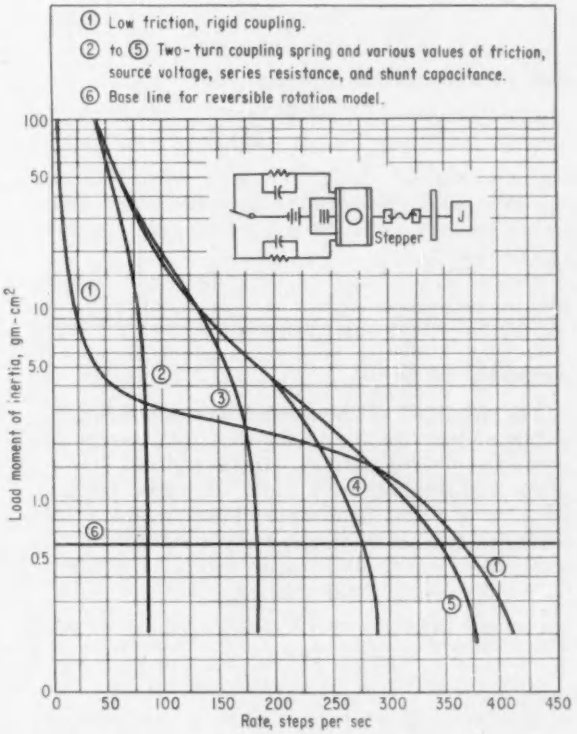


FIG. 6. Typical inertia-speed curves illustrating the effects of varying the mechanical and electrical parameters in the circuit shown at the upper right.

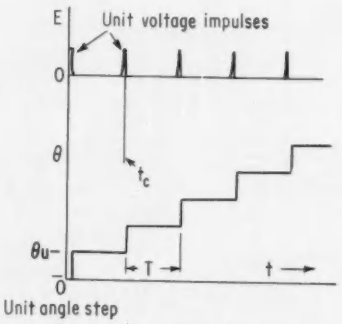


FIG. 8. Staircase output produced by a series of unit impulses.

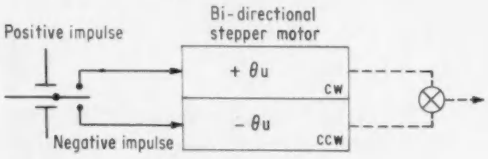


FIG. 9. Simplified schematic of a bidirectional stepping motor.

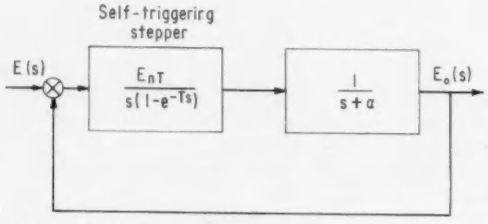


FIG. 10. Block diagram of a self-triggering stepper in a closed loop.

regarded as an infinitesimal summing device or true integrator:

$$\theta_o(s) = E(s)\,\frac{1}{s} \tag{11}$$

where $E(s)$ is a function of time which has been sequentially sampled at a relatively high rate.

In many steppers bidirectional stepping is achieved through dual actuating elements for cw and ccw rotation. Consider the device as shown in Figure 9. The net angular output would be:

$$\theta_o(s) = \frac{+\theta_u}{s}\sum e^{-(n-1)Ts} + \frac{-\theta_u}{s}\sum e^{-(m-1)Ts} \tag{12}$$

where n is the number of cw steps, and m is the number of ccw steps.

In the time domain: $\theta_o(T_{m+n}) = (n-m)\theta_u$ (13)

where T_{m+n} equals $(n+m)T$. A negative result indicates a net rotation counterclockwise.

Self-triggering stepper

An incremental servo which will accept an analog input $f(t)$, sample it sequentially with periodicity T, and yield a sequence of values of $f(t)$ is termed self-triggering and would have the transform:

$$K(s) = \frac{E_{nT}}{s(1-e^{-Ts})} \tag{14}$$

where E_{nT} is the value of the nth sample and $T<<T_D$.

In z-transform notation this equation becomes

$$K(z) = \frac{E_{nT}}{(1-z)(1-z)} \tag{15}$$

Here the (1-z) binomials are expressed separately to emphasize that they do not have identical meanings. One of them expresses the impulse modulating nature of the device and the other its staircase generating characteristic. The entire equation expresses the operation of an incremental sampling servo.

Such a device when followed by continuous frequency elements enclosed in a unity feedback loop (Figure 10) would have the s-transform response:

$$R(s) = \frac{E_{nT}}{1-e^{-Ts}} \times \frac{1}{s(s+\alpha)} \tag{16}$$

The first term in this equation expresses the incremental portion, and the second combines the continuous frequency portion of the self-triggered stepper with the exponential decay network. A sequential sampler followed by a continuous frequency network has the closed-loop z-transform:

$$R(z) = \frac{1}{(1-z)} \times \frac{G(z)}{[1+G(z)]} \tag{17}$$

and Equation 16 therefore becomes:

$$R(z) = \frac{E_{nT}\beta z}{(1-z)(1-z)(1-\gamma z)} \tag{18}$$

where γ equals $e^{-\alpha T}$, (1-z) (1-z) represents a staircase function, $(1-\gamma z)$ a staircase step decay, z the delay of all staircase steps by T seconds (e^{-Ts}), and β equals $(1-e^{-Ts})/\alpha$.

Further information on closed-loop z-transforms and jump function analysis may be found in any of the last three references listed below.

Steppers at work

The third part of this series will cover the application of the stepping motor to a wide variety of incremental servo systems. Block and circuit diagrams will illustrate such widely divergent applications as a digital differential altimeter, a rail car sorting system, and a simple asynchronism detector.

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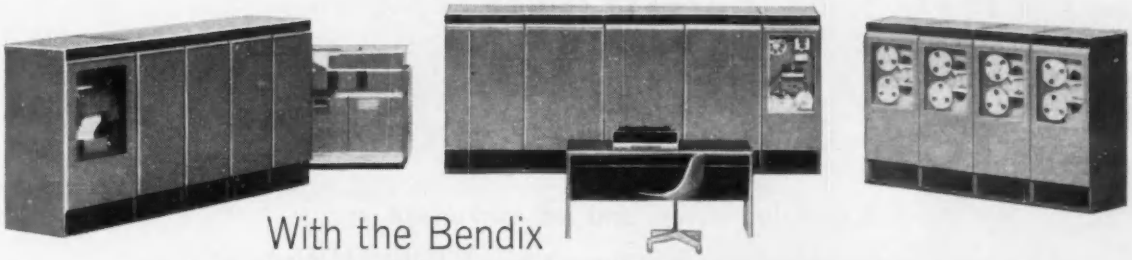

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Hints for Improving Relay System Reliability

1. Watch out for relay mutual and self-contamination
2. Specify connecting wires that won't break through fatigue
3. Use higher voltages across dry circuit contacts
4. Check contact failure characteristics of relays

BYRON K. LEDGERWOOD
Control Engineering

When two identical relays performing under identical circuit conditions are placed one above the other in a relay enclosure, which will be the most reliable, the upper one or the lower? And which is better: rigidly mounted relays with seven-strand wire or grommet mounted relays with 19-strand wire? These are the sort of mundane problems that the systems engineer often does not consider. But they may affect over-all systems reliability much more than would leaving out the interlocks, redundant circuits, and other reliability-insurance techniques that he has incorporated in the course of a complex control system analysis and design.

Allen-Bradley Co.'s research personnel ran extensive tests to investigate the importance of some of these often overlooked relay application factors. The following reports on four areas that were studied: 1) relay contamination, 2) connecting wire breakage, 3) dry circuit switching, and 4) typical industrial control relay failure curves.

1. RELAY CONTAMINATION

The most important cause of relay electrical failure is the bits of nonconductive material on the contracts, preventing contact closure. The strange thing is that most often these contaminants are generated by the relay itself or by a second relay located above the first.

Figures 1 and 2 give some idea of the contamination generation potential of typical relays. Figure 1 shows a sealed case used for the parallel testing of relay electrical reliability as described in the reference. The relays mounted in the case are operated simultaneously until one contact on one relay fails to make or break, at which time the test shuts down until the failure is noted and the equipment is restarted manually. A shows the case prior to the start of a test, while B shows the same setup after 1 million operations. Note the quantity of relay-generated dirt at the bottom of the case in B, shown in more detail in Figure 2. This is dirt that would fall down and contaminate lower relays if there were relays mounted below, a situation commonly encountered in the conventional industrial relay enclosure.

To verify the effect of relay mutual contamination, tests were run to determine the relative reliability of relays mounted in a 3 x 3 matrix, Figure 3. The plot shows operations per failure in percent of top row failures and is the result of three separate tests on two different types of relays. The data are scattered since the tests were run for only 1 million operations and since there are variations from relay to relay and in the type of relay construction. Relays with their contact structure shielded from falling particles, for example, show less difference in failure rate than do relays with open contacts. (Hermetically sealed relays should show no difference.)

But in every test that was run—all tests using standard industrial control type relays with accessible contacts—the relays on the lower two rows failed more frequently than the relays in the top row. This would indicate that relay system reliability can be improved by avoiding mounting one relay over another or by including a shielding partition between horizontal rows.

A further increase in reliability can be achieved by selecting relays that generate a minimum of dispersed contaminant and that do not contaminate themselves. In particular look out for relays in which insulating materials in the immediate vicinity of the contacts rub against other insulating materials or against metallic materials. This rubbing action be-

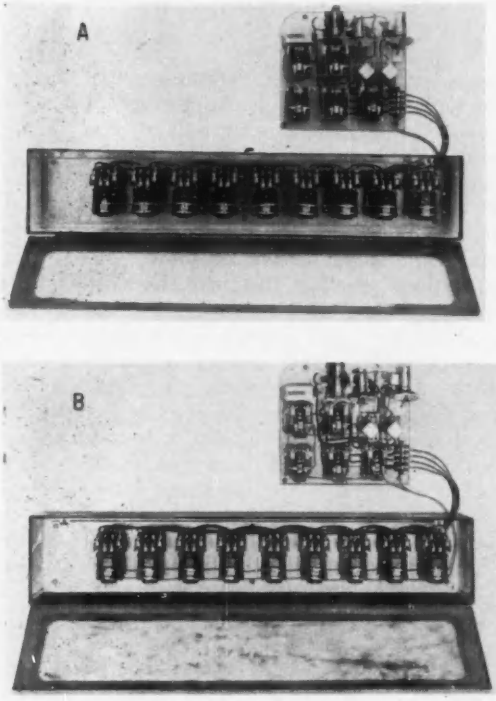

FIG. 1. A—Relay test enclosure before start of test and B—after one million operations.

tween wearable materials is what generates dirt and nonconducting particles.

Some industrial control relays have a greater tendency to contaminate themselves than do others. In an effort to improve relay mechanical reliability, industrial relays have been designed with enclosed contact structures. This prevents dirt from the relays above from reaching the contacts and often yields a relay that has excellent mechanical life, but at the same time it prevents the self-generated contaminants from escaping from the vicinity of the contacts. In the long run this results in a severe decrease in electrical reliability because of self-contamination. Avoid relays where the dirt cannot fall away from the immediate vicinity of the contact structure.

RELAYS GENERATE DIRT

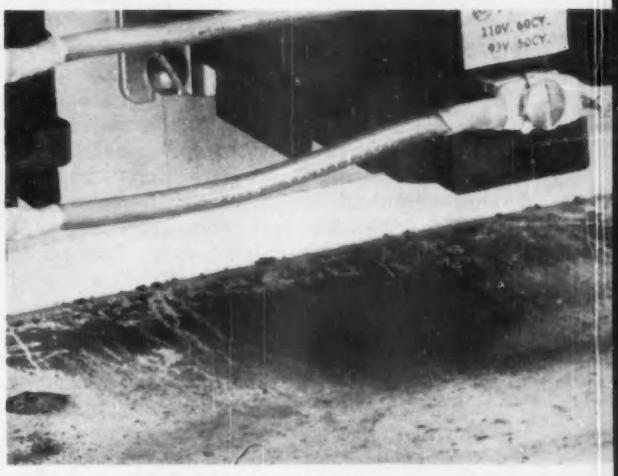

FIG. 2. Closeup of test enclosure shows dirt generated by one relay after 1 million operations.

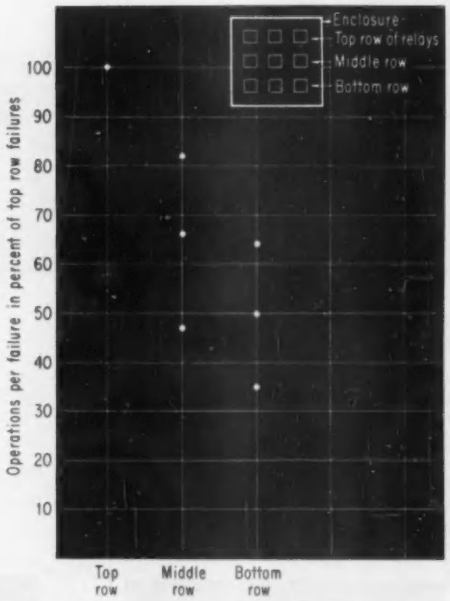

FIG. 3. Effect of relay position in enclosure on failure-to-make rate. In every case the relays on the lower two rows failed more frequently.

2. CONNECTING WIRE BREAKAGE

Wire connections to relays can play an important role in system reliability. Careless installation can cause breakage of the connecting wire between wire and terminal, wire and lug, or even breakage of the lug itself. Too frequently nonspecific assembly instructions or the desire to save copper can result in wiring that is under sufficient tension to cause excessive stresses in the wires, particularly if there is terminal motion with respect to wire mountings.

Tests were run to determine the effect of connecting-wire slack, wire type, and relay mounting on wire breakage. The relays were mounted on an angle bracket with the under side of the angle 2½ in. above the center line of the terminals, Figure 4. Wires were anchored on the top side of the angle so that any wire flexure had to take place between the under side of the angle and the relay terminals. Tests were run with no slack in the wires, Figure 4A, and with varying amounts of slack (Figure 4B shows 2 in.). Seven and 19-strand No. 14 gage wires were

employed with solid and grommet mounted relays.

The most extensive tests were made with 19-strand No. 14 gage wire connected to four-pole relays mounted on resilient grommets. Wherever a breakage occurred, the wire was replaced to simulate actual operating conditions with a fully wired relay. If a second failure of the same lead occurred, the incremental number of operations was used for analysis. Wire failures are expressed in percentage of the total number tested and as a function of the number of operations of the relay.

Figure 5A shows the results for the original $2\frac{1}{8}$-in. wire and for 1-in. and 2-in. longer wires. With no slack the initial failures occurred after about 7×10^6 operations. However, as replacement wires were installed and the tests continued, some subsequent failures of a particular wire occurred after only 1 or 2 million operations. Thus the curve of percent failures vs number of operations starts at about 1 million. The reason for this behavior is not clear but may be due to slight variations in initial tension in the replacement wires. It may also reflect changes in the operation of the relay due to wear of the moving parts or increasing grommet flexibility.

The curve shows that about 50 percent of the wires were broken after 20×10^6 operations, but at 40×10^6 operations the number broken had increased to only 70 percent of those tested. This apparent leveling off of the curve short of 100 percent is explained by a statistical analysis of the data which shows that the failures are not described by a single normal distribution curve, but by a combination of several such curves. Breakages follow several distribution patterns, depending on location of the terminal to which the wire is connected.

With the wires having 1 in. of slack, initial failures started at about 12×10^6 operations with about 17 percent of the wires broken at 20×10^6 and about 40 percent broken at 40×10^6 operations. With the wires having 2 in. of slack, initial failures started

PROPER WIRING CAN IMPROVE RELIABILITY

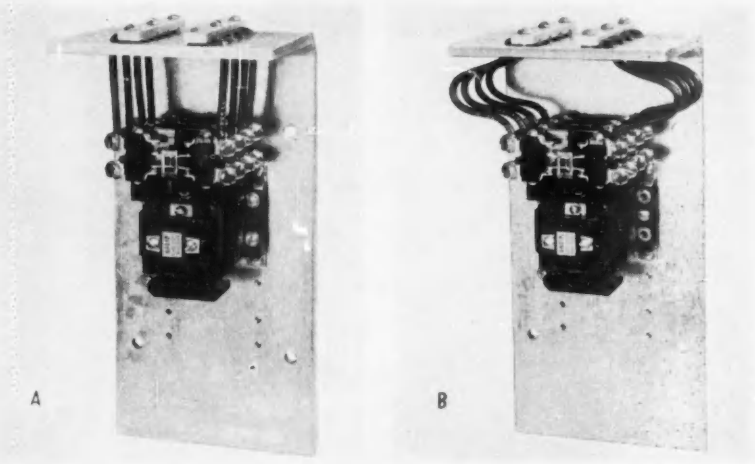

FIG. 4. A—Test relay with no slack in connecting leads and B—with 2 in. of slack.

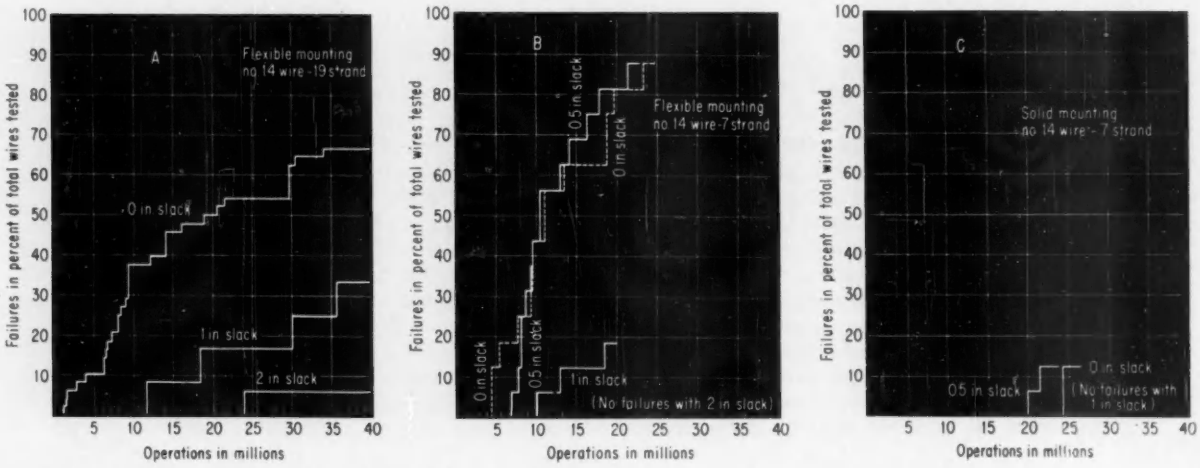

FIG. 5. Wire breakage test results for different wires and different relay mounts.

at 24 $\times$ 10^6 operations, but only about 6 percent had failed at 40 $\times$ 10^6 operations.

The tests using seven-strand No. 14 gage wire and relays with resilient grommets were made slightly differently. They were started with the relays fully wired, but no replacements of the broken wires were made during the test. Figure 5B shows that the failures started at 4.5 $\times$ 10^6 operations and increased steadily, approaching 100 percent for the wires with no slack. Observations made during the test disclosed that the full set of connecting wires appreciably added to the stiffness and reduced relay motion. As the wires progressively broke, the remaining wires were more highly stressed and failed more rapidly. This indicates that if only one or two poles of a four-pole relay were wired this way, the failure rate would be higher than if fully wired. Surprisingly, the ½-in. longer wires showed practically no change in breakage rate. The wires 1 in. longer showed a considerably reduced breakage rate, and the wires 2 in. longer showed no failures at all up to 40 $\times$ 10^6 operations.

Since these two tests were made on a different basis, an exact comparison cannot be made, but the advantage would seem to be in favor of the 19-strand over the seven-strand wire.

The tests made with the solidly mounted relays also used seven-strand No. 14 gage wire. Figure 5C shows a small percentage of failures starting to occur after 20 $\times$ 10^6 operations when the wires had no slack and ½-in. slack. With the 1-in. longer wires no failures occurred up to 45 $\times$ 10^6 operations.

The test show that fatigue failures of the connecting wires may begin after a few million operations. This breakage can be reduced to negligible levels by increasing the flexibility through the use of finer stranded wire and by using up to 2 in. extra length in the leads. In the most severe cases a solidly mounted relay provides more assurance against wire breakage and is not so demanding of the manner in which the relay is wired.

3. DRY CIRCUIT SWITCHING

Dry circuit switching (where the contact carries current but does not make or break a circuit—an interlock, for example) always presents electrical reliability problems since there is no making or breaking of current to burn away the contaminants on the contact surfaces. Tests were run to determine the relationship between circuit voltage and the failure to make of dry contacts. Figure 6 shows the results: there is a considerable decrease in failure rate as the voltage is increased.

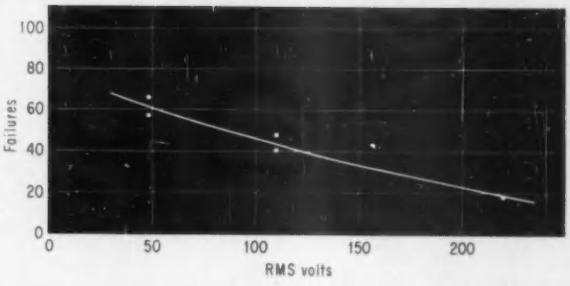

FIG. 6 Failure of dry contacts to make vs circuit voltage.

4. TYPICAL RELAY FAILURE CURVES

A log-log plot of contact reliability tests for several makes of relays is shown in Figure 7. These are averages of results on a number of relays so that the shapes demonstrate the failure characteristics of a relay line rather than the peculiarities of a single unit. Only electrical failures are considered.

Note that relay 1 initially shows a higher failure rate than either 2 or 3, but that later 1 turns out to be greatly superior. Relays 2 and 3 are initially about the same, but in time 3 turns out to be considerably poorer. In the case of 3 the failures as indicated by the 1 to 1 slope of the curve would appear to be essentially random in character, whereas in the case of relay 1 the failures, instead of increasing linearly with operations, increase roughly as the cube root of the number of operations. Relay 2 shows quite different characteristics since the slope, and thus the rate at which failures are accumulated, seems to change with respect to the number of operations.

While these results are difficult to explain, they can be duplicated, so that they are definitely caused by some characteristic of basic relay construction. A large user of relays would be wise to consider the failure characteristics of several types of relays to find the one best suited to his application.

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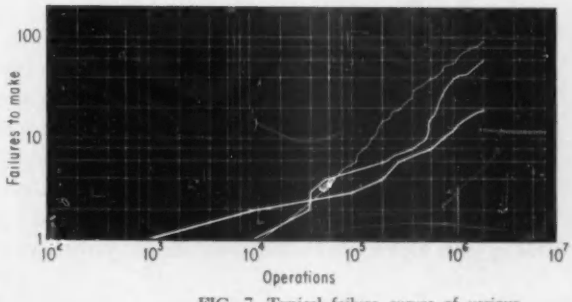
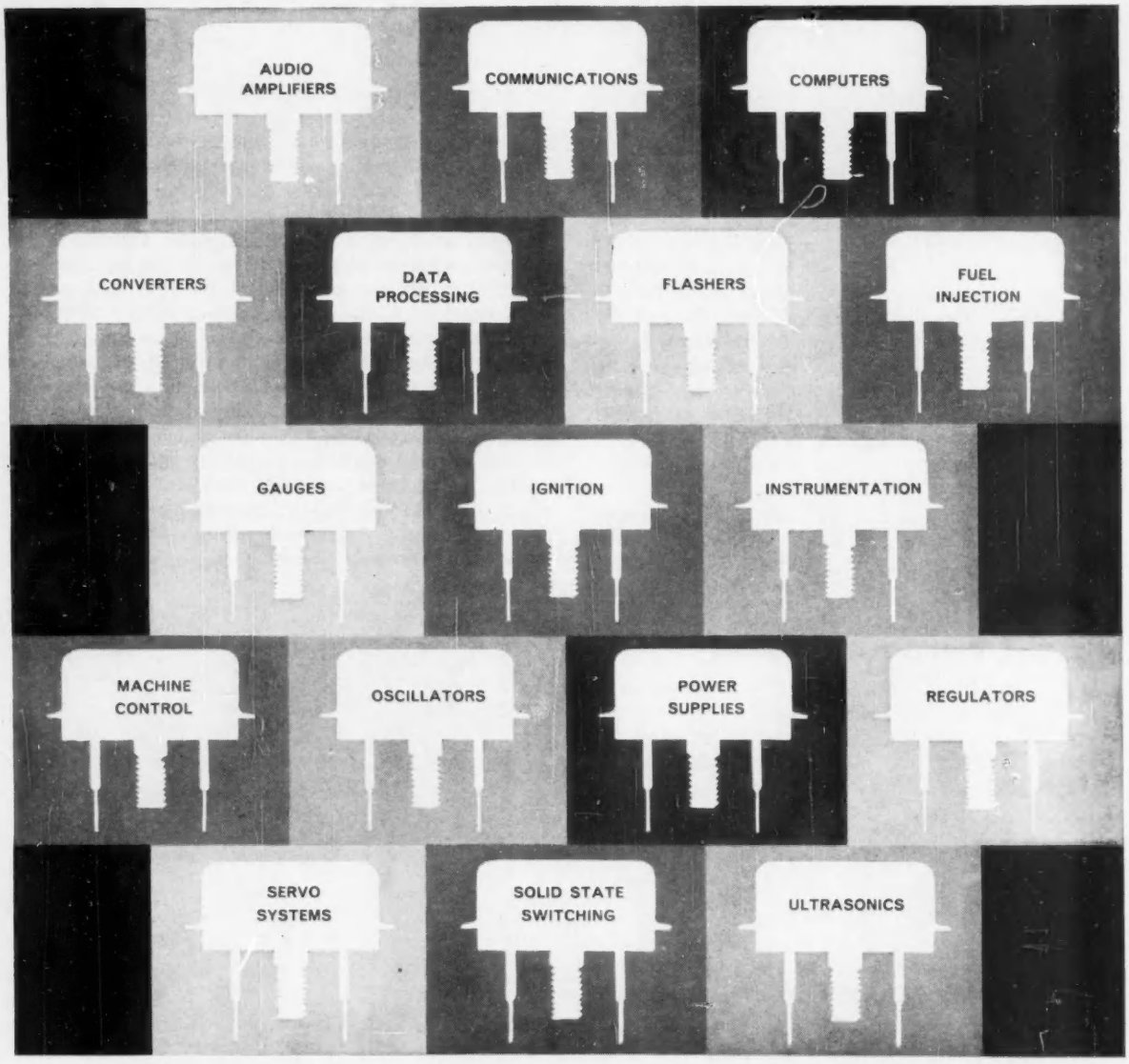


FIG. 7. Typical failure curves of various makes of industrial control relays.



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Infrared Analyzer Controls Hydrocarbon Extraction Process

Closed-loop control of processes with stream analyzers represents a rewarding area for upgrading the products value of operating plants. A typical instance of this approach is described here. Results: Propane giveaway reduced by about $7,000 per year, plus additional savings from eliminated control lab analyses.

D. M. STAGG, J. PRZEWOZNIAK, and L. W. HERSCHER, The Dow Chemical Co.

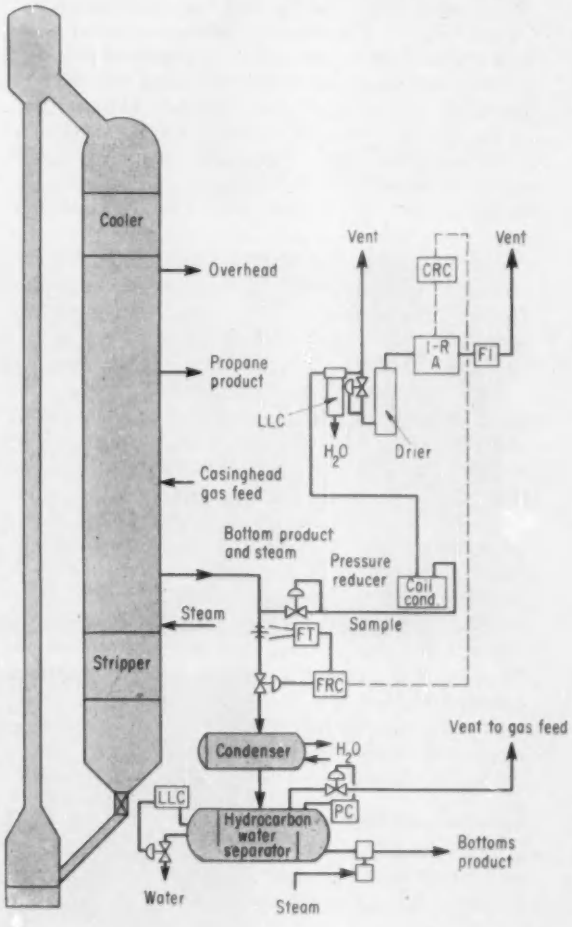
To improve hydrocarbon extraction efficiency at one of Dow's plants, an infrared analyzer now measures the iso-butane concentration of the bottoms product stream of a hypersorber. And in conjunction with a cascade control system, it regulates the bottoms product flow to maintain the concentration at a desired value. The hypersorber and its over-all control system are shown in Figure 1. The feed to the hypersorber is a casinghead gas stream which is separated—by a moving bed of activated carbon in the column—into three streams: an overhead of methane and ethane, a valuable side product of propane (liquified and sold as bottled gas), and a bottoms product of butanes and higher molecular weight components.

To get the maximum amount of propane and yet keep the butane content of the C_3 product within specification limits, the bottoms product stream flow must be closely controlled. Too much flow permits the propane concentration in the bottoms stream to build up, thus putting excess propane into the lower priced product. Too little flows allows the butanes to build up in the column and eventually contaminate the propane side product. The problem was to find a correlation between concentrations and flow and then to design a bottoms stream flow control system that maintains concentrations.

The correlation was determined by employing the gas chromatograph already used in the plant to continually check propane product quality. Putting several samples of the bottoms stream taken under various processing conditions through the chromatograph and studying the results indicated that the iso-butane concentration in this stream varied inversely with propane concentration and directly with flow rate. Said another way, the tests quantitatively verified that bottoms stream flow rate affected iso-butane concentration.

Since an infrared analyzer is quite effective for continuously determining iso-butane concentration,

FIG. 1. Hypersorber, left, for hydrogen extraction has bottoms product stream controlled from on-line infrared analyzer.



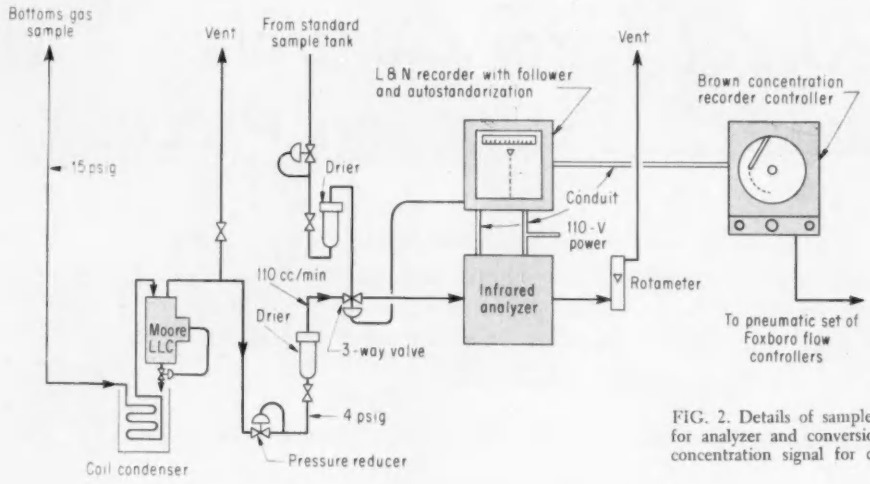


FIG. 2. Details of sample handling system for analyzer and conversion of concentration signal for cascade control loop.

such an instrument was selected as the basic measuring element in the bottoms-stream flow control system. The bottoms gas stream leaving the hypersorber contains 80 percent steam. Steam introduced into the column strips the C_4 and heavier hydrocarbons off the carbon. Therefore the instrumentation in the flow control loop must include a means of setting a positive minimum flow rate to insure constant removal of all the steam and stripped hydrocarbons.

The infrared analyzer chosen for the system is of the negative filter type. Its 5-cm long sample cell is traversed by both analyzing and reference infrared beams. Sensitization to iso-butane and freedom from interference from changes of the other stream constituents is obtained by filling the cell's reference-beam side with iso-butane to 688 mm of Hg and ethane to 52 mm and filling the analyzing-beam side with 610-mm propane and 10-mm normal butane. These fillings were determined empirically.

Figure 2 shows the sample handling and analyzing systems. The gas sample taken at the bottoms line orifice tap is put through a pressure reducer and then a condenser. Pressure reduction prevents the hydrocarbons from condensing with the steam. A Moore liquid level controller separates the steam condensate from the hydrocarbon gases. At this point a large portion of the sample is vented, keeping the lag time from the sampling point to the analyzer at a minimum. The part of the sample to be analyzed first passes through another pressure reducer, dropping the pressure to slightly more than atmospheric, and then passes through a bed of Drierite, drying the sample before it enters the infrared analyzer. After leaving the analyzer the sample flows through a rotameter and is vented to atmosphere.

Cascade control arrangement

The infrared analyzer output signal goes to a Leeds and Northrup strip chart recorder at the analyzer location. An automatic standardizing system in the recorder introduces a known composition hydrocarbon gas sample to the analyzer every 1½ hr, automatically correcting any drift off standard. A follower in the L & N recorder picks up the iso-butane concentration reading and transmits it to a Minneapolis-Honeywell (Brown) round chart pneumatic recorder-controller, with proportional and reset control modes, located in the control room.

The pneumatic output from the recorder-controller cascades into a Foxboro pneumatic-set flow recorder controller, on which the pneumatic-set is adjustable from 0 to 100 percent of full scale. With this arrangement the bottoms gas flow can be controlled over any desired range and with any preset minimum flow. If necessary, the Foxboro flow recorder-controller becomes a simple flow controller merely by putting the Brown on manual control, thus bypassing the infrared control system.

The infrared analyzer control system—in constant use during 12 months of plant operation—has given continuous, reliable automatic control of the bottoms gas stream. The cell design, good sample handling and preparation system, and rugged protective analyzer housing all contribute to the analyzer's accuracy and reliability.

Analyzer maintenance, handled by a Dow Instrument Dept. route man, requires an average of less than an hour per week. The sample cell has failed only once: the infrared-source cooling water coils plugged off. The only operator attention required is the resetting of the minimum flow on the Foxboro FRC when steam rates change and the occasional resetting of the control point on the Brown CRC when column conditions change.

Using an infrared analyzer in this closed-loop control system has brought about an estimated $20 per day increase in products value by minimizing propane loss in the bottoms stream. Additional savings result from the elimination of control lab analyses to check the efficiency of the operation.

DATA FILE 43

A Simple Template Makes Bode Plots Easy

C. A. STAPLETON, *The University of New South Wales, Sydney, Australia*

The plastic template or rule described here simplifies the making of accurate Bode frequency response plots and can save considerable time if such plots are made frequently.

The Bode diagram is often used by control engineers to plot the frequency response of a system or control component. In the Bode plot the logarithm of frequency is used as the abscissa, while phase shift in degrees and the logarithm of the input-output magnitude ratio are plotted separately as ordinates.

The heavy lines in Figure 1 are a typical Bode diagram (for a term of the form $1 + j\omega/\omega_b$, normalized around the break frequency ω_b). The dotted straight lines approximate the actual plot of the function with a maximum error of 6 deg in phase angle and 0.15 in log magnitude ratio. These dotted lines represent the asymptotes of the actual function and have discrete slopes of either zero or one per decade of log frequency for the magnitude ratio and of zero or 45 deg per decade for phase angle. Slope changes always occur at ω/ω_b for the magnitude ratio and a decade above and below ω/ω_b for the phase angle.

Bode plots of higher order functions have slopes which are integral multiples of one (i.e., 2, 3, 4, . . .) per decade for the magnitude ratio, and integral multiples of 45 deg (i.e., 90, 135, 180, . . .) per decade for the phase angle.

The Bode rule

A plastic template designed to simplify making accurate Bode plots, Figure 2, has three main features:

—*The slope vees*—Placing one side of the correct slope vee on a horizontal inclines the edge of the rule so that it can be used as a straight edge to draw the slope. The rule shown has been designed for graph paper on which 1 in. vertically is one unit of log magnitude; three decades of log frequency occupy 10 in. horizontally.

—*The magnitude correction*—This curve permits plotting an accurate graph of the desired log magnitude function (again only on the correctly scaled paper) by direct measurement from the asymptotes plotted with the slope vees. Note that the error between the asymptotes and the function is symmetrical about ω_b and is plotted for a decade either side of ω_b in the lower right hand sector of the rule.

—*The angle correction*—This error plot requires a sign change on either side of ω_b, but the error is symmetrical about ω_b and the 45 deg slope. The simple convention which determines the sign of the error is on the rule.

The correction curves on the rule can be used directly for single term functions only. They must be multiplied by the appropriate integral factor to correct higher order functions.

In actual plotting of Bode diagrams, the complete plot is usually the sum of contributions from individual factors in a multiple term function. Straight line approximations are valid, but the changes in slope will in general not be from zero. It is helpful therefore to mark the frequencies at which slope changes occur along a convenient horizontal with small arrows which indicate the direction of change, "up" or "down". This technique is particularly useful in making the angle plot, where the slope changes are a decade away from ω_b. The plot can then be drawn in one operation from left to right starting at zero (or log K if the dc gain is K rather than unity) and zero degrees, changing slope as required at each arrow. The sign of the slope change is indicated by the direction of the arrow.

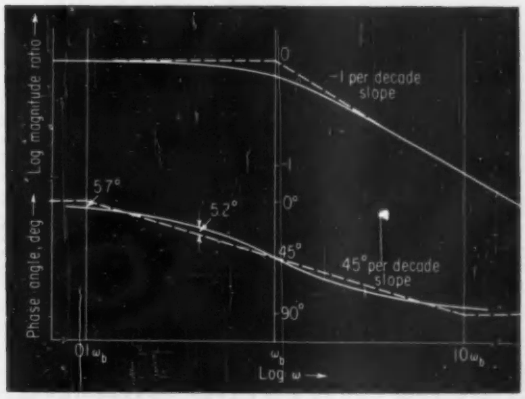


FIG. 1. A typical Bode diagram.

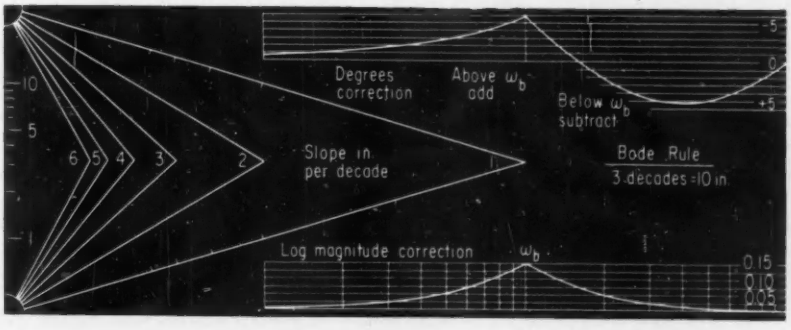


FIG. 2. The Bode rule, scaled down from 4 x 10 in. original.

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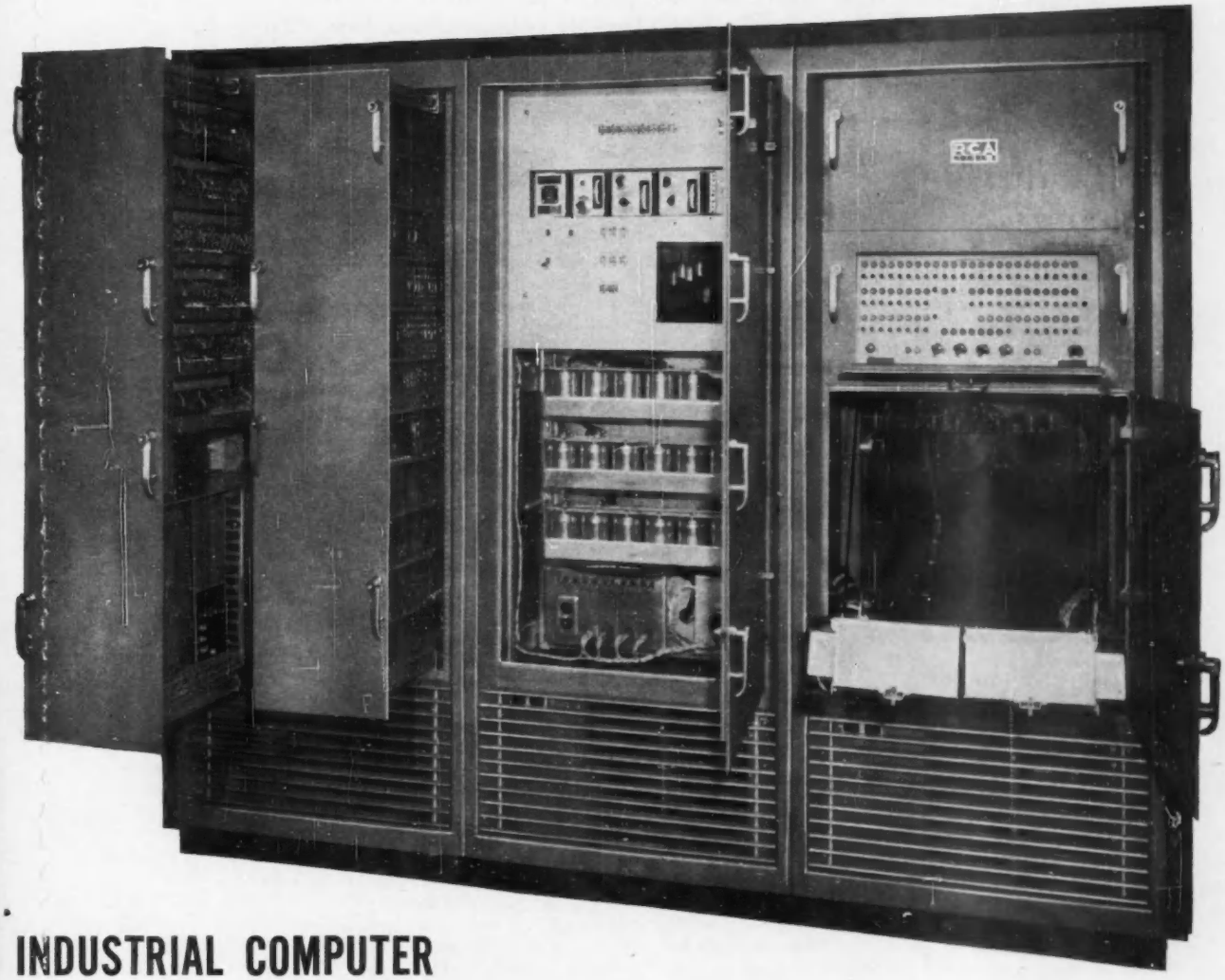
Industrial Computer System



INDUSTRIAL COMPUTER

EASY MAINTENANCE EVEN DURING OPERATION—all circuits accessible from front in extendable drawers and hinged chassis. Industry's most complete maintenance panel permits manual check-out of complete system. Computer continues to operate with all drawers fully extended. Circuits are designed to perform at high temperatures—have built-in marginal testing, and an automatic alarm signals improper operating voltages.

MODULAR DESIGN PERMITS FIELD EXPANDABILITY — both drum and core memories can be expanded in the field within a few hours as additional tasks are assigned to the computer or the number of inputs, outputs, and data manipulations are increased.

COMPARE THESE PERFORMANCE SPECS

Speed — including access time and staticizing, adds in 56 microseconds, multiplies in 728, divides in 868. *Instructions*—one address (limited two address), 7 indexable address registers, 71 wired-in instructions. *Number System*—fixed point, binary or binary coded decimal. 24 bit word length, word time 28.89 microseconds. *Working Storage*—magnetic core, coincident current, variable in size from 256 to 4096 words, 8 high-speed input-output registers, clock frequency 936 kilocycles. *Bulk Storage* — magnetic drum, 3600 rpm, 4096 to 51,200 words, 8.3 milliseconds average access time, 200 kilocycle transfer rate, up to 12 buffer tracks for input-output. *Size*—82" high, 34" deep, 105" long. *Typical Power Input*—5 kva, 220 volts.

Digital Logic Improves Photoelectric Length Measurement

THE GIST: In themselves, photoelectric devices provide sufficiently high resolution to measure sheet length to within plus or minus 0.001 in. In actual applications, however, "on-line" variables (notably strip speed and skew) make it difficult to achieve control system accuracies to much better than plus or minus 0.003 in. Pulse circuitry makes it possible to compensate for these variables and realize the full potential of photodiodes as noncontacting gages.

ROBERT B. STERNS, Logic Systems, Inc.

Tinplate shear lines require accurate control of sheet length to prevent jamming of container-making machines, insure product quality, and provide most economical use of material. In terms of specific design objectives, an optimum control system must be able to spot and reject any sheet that is either 0.005 in. too long or too short and must give the measurement of each sheet to within plus or minus 0.001 in. Sheet speed can range from 50 to 800 ft per min.

Photoelectric techniques offer many advantages for this type of problem: They provide inherent resolution that is adequate for the application. And they do not involve the mechanical wear and slippage characteristic of contacting-type transducers for length measurement. On the other hand, the performance of the usual photoelectric system depends to a great extent on close regulation of line speed and careful positioning of the moving sheets on the conveyor. If the tinplate sections are subject to skew or if line speed is allowed to fluctuate, control accuracies are severely limited. For example, if a 44-in. wide sheet enters the scanning area at an angle of only 1 deg from the axis of the conveyor line, the length of scan is increased by 0.007 in.

Multiple photodiode scanners working into pulse circuity provide the answer to skew and speed regulation problems. The design concept makes use of "error" time and "inch" time to gain complete independence of speed variations. In addition, the combination of offset photodiodes and a coincidence detector provides automatic compensation of skew. These features are now incorporated in a packaged control system specifically designed for shear line use.

Operation

The DA 214 control is capable of measuring sheet length to an accuracy of plus or minus 0.001 in. while compensating for skew of as much as plus or minus $\frac{7}{8}$ in. on a 44-in. long sheet. Sheets travelling on a flat conveyor at lineal speeds up to 800 ft per min, spaced at least 3 in. apart, can be measured. The flexible control can be equipped for visual indication and digital printout and to furnish reject signals for sheet lengths greater or less than prescribed limits. Because the entire electronic circuit is digital, a high degree of stability is maintained. A block diagram of the control system is given in Figure 1.

Five photodiodes act as sensing elements: three determine speed and length, and two determine skew. These photodiodes are located as shown in Figure 2. Photodiodes 1 and 2 measure the speed of the leading edge of the sheet. Photodiodes 1 and 3 measure the variation of sheet length from set length L. Photodiodes 4 and 5 sense the length error introduced by sheet skew. During the length of time between the cutoff of diode 1 and then of diode 2 by the leading edge of the sheet, the output of a 1-kc oscillator is gated open. This allows a discrete number of pulses to pass, the number being proportional to the speed.

If the sheet is exactly L in. long, the leading edge cuts off photodiode 3 at exactly the same moment as photodiode 1 is reenergized by the departure of the trailing edge. If the sheet is longer or shorter than L in., there is a time interval of coincidence during which both diodes 1 and 3 are on or off simultaneously. As long as such coincidence exists, a 1-Mc oscillator is gated open. The number of pulses that is allowed to pass is proportional to the variance in sheet length above or below the prescribed figure. To find the true error in length, however, it is necessary to take speed into account. This is done by dividing the number of sheet-length error pulses by the number of speed pulses, which yields the actual length error in thousandths of an inch.

For an example, assume that the speed is 100 ft per min and sheet length is L plus 0.008 in. Because the time required for 1 in. of travel is 50 millisec, photodiodes 1 and 2 gate a total of 50 1-microsec pulses. At a speed of 100 ft per min, the sheet takes 400 microsec to travel 0.008 in. Thus, as a result of the plus 0.008 in. error, there is a 400-microsec overlap between the triggering of diode 3 and the cutoff of diode 1. During the interval of overlap, a total of 400 1-microsec length error pulses are gated. The counts of 400 and 50 stored in the register are now divided to yield the actual length error of 0.008 in. If sheet speed were 500 ft per min, the register counts would be 10 speed pulses and 80 error pulses. These numbers, too, yield a quotient of 8, equivalent to the

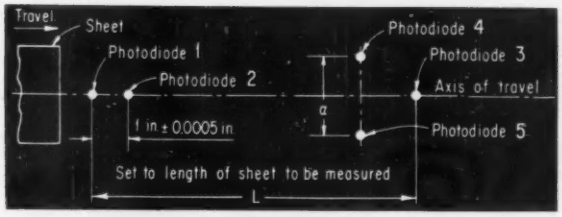
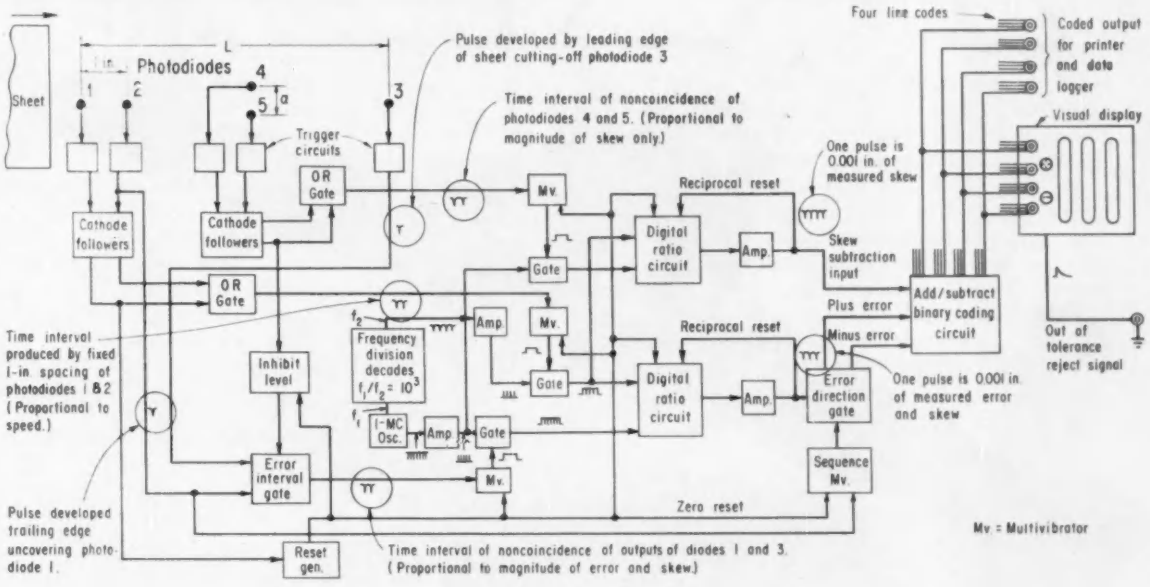


FIG. 2. Location of photocells with respect to axis of travel.

FIG. 1. Block diagram of photoelectric length gage.



0.008-in. error in length. It is seen that error measurement is independent of speed.

Skew compensation

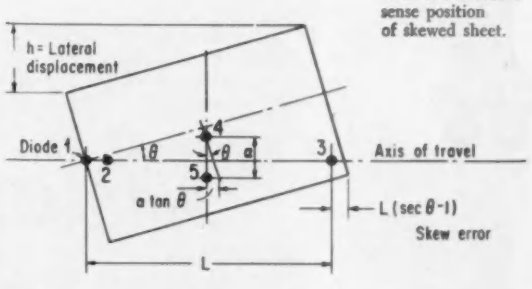
When the axis of the sheet is parallel to the axis of conveyor travel, the measured length error is equal to the actual error. However, if the sheet axis is at some angle θ from the conveyor axis, the measured error is larger than the true error by an amount designated as "skew error", Figure 3. Skew error is mathematically equal to $L(\sec \theta - 1)$. Unfortunately, this expression is a function not only of the angle of skew and of basic length, but of length error as well. A quantity proportional to skew only and independent of length error is a tan θ, which is easily found by measuring the time interval between the cutoff of diode 5 and the cutoff of diode 4.

For certain values of a, the actual skew error $L \times (\sec \theta - 1)$ is practically equal to the measurable skew error a tan θ (within 0.001 in.). When L equals 44, a value of 0.37 in. is selected for a. In this case the measured skew error does not differ from true skew error by more than plus or minus 0.001 in. for lateral displacements (h) of plus or minus $\frac{7}{8}$ in. When L is 22 in., a value of 0.25 in. is assigned to a. In this case the limit for h is $\frac{3}{8}$ in. if the measured skew error is to be held within plus or minus 0.001 in. of the actual skew error.

The action of diodes 4 and 5 gates the output of a 1-Mc oscillator to produce a stream of pluses proportional to the magnitude of a tan θ. Here again this measurement is dependent on the speed of travel of the sheet. Thus the number of gated pulses must be divided by the number of speed pulses to yield the true value of skew error. Finally, the measured length error and the measured skew error are added to give the full deviation from the set length L.

The photodiodes used in this application have response times of 1 or 2 microsec. They are held in micrometer-type mountings for easy and accurate adjustment of the a and L settings. Any error is visually displayed and retained as a four-line code for printout or control until the output circuits are reset by the next sheet. A reject signal is generated when the sheet length error exceeds plus or minus 0.005 in. The output signal operates and holds a reject relay for 0.03 sec.

FIG. 3. Photocells sense position of skewed sheet.



Wind Tunnel Interrupts 709 For Fast Data Reduction

A new high-speed data transmission system and the interrupt feature on the company's IBM 709 computer give McDonnell engineers reduced test data at their new polysonic wind tunnel in plotted form within 15 min after completion of a run. The engineers can thus determine if the projected test schedule should be changed before the next run. They may add to or change conditions set up for the next test, or they might even be able to cancel several proposed runs because they know that they already have the information sought.

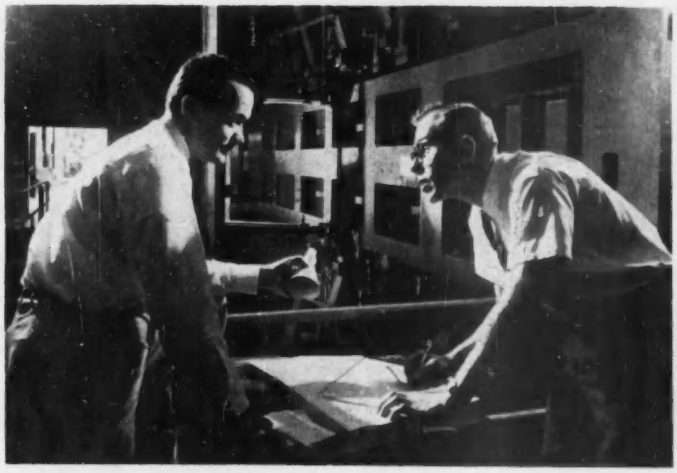
Operating costs on the polysonic wind tunnel (Mach 0.5 to Mach 5.0) run to nearly $600 per hour, and thus it would pay well from this standpoint alone to reduce tunnel "occupancy" time as much as possible for any one aircraft or space vehicle. It is much harder to put a dollars and cents figure on reduced development time, but the difference between winning a contract or seeing it go to a competitor sometimes hinges on submitting a completed proposal in time.

The data collected from transducers on the model under test are converted to digital form, transmitted to the computer more than two miles away, reduced, returned to the wind tunnel, and recorded—all virtually automatically. The following picture-caption story shows the equipment and procedures used in this high-speed data system.

T. M. BELLAN, McDonnell Aircraft Corp.

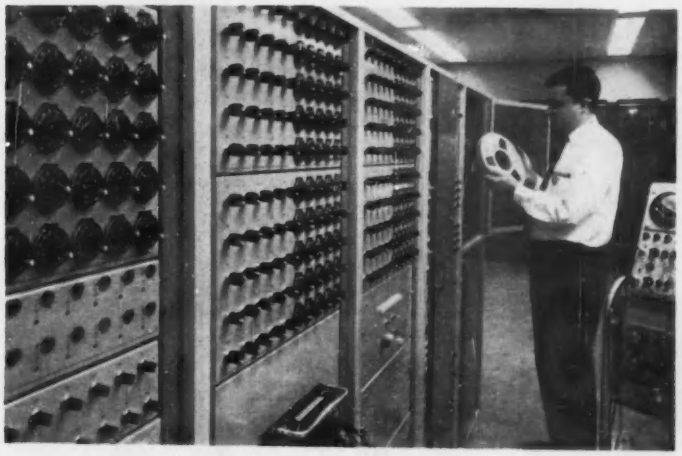
1.

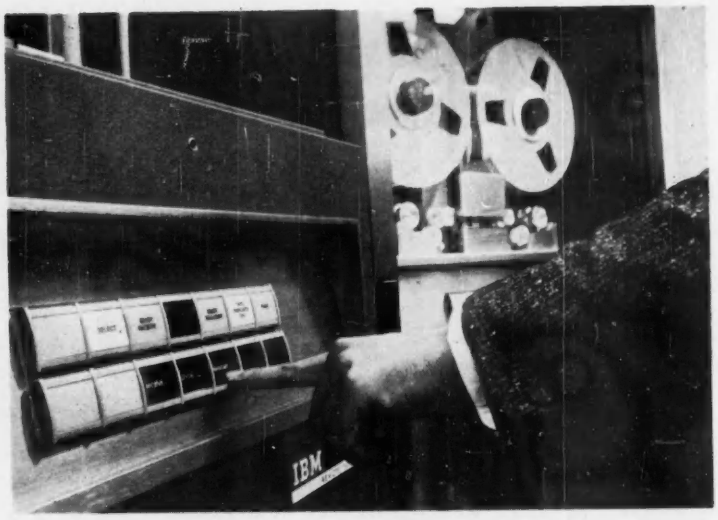
McDonnell engineers William Becker (left) and Russell Cassidy check a graph plotted automatically by their new data reduction system. The magnetic tape on the table is used to transmit the test information to the 709, and the punched cards and tabulated printer listing under the graph paper provide permanent records of the test for further analysis later if desired. The structure in the background is part of the new polysonic wind tunnel . The tunnel is of the blowdown type, in which compressed air stored in large outside tanks is allowed to expand through the 4x4x4 ft test section by opening a large valve. Mach number in the test section is controlled by the opening of the valve and the adjustment of a nozzle with plates 4 ft high by 15 ft long. A blow lasts from 100 sec at Mach 0.5 to 10 sec at Mach 5.0.



2.

Analog data collected from pressure pickups, strain gages, thermocouples, and other transducers within the model under test in the wind tunnel are brought out through the sting on which the model is mounted and converted into digital signals by this Consolidated Electrodynamics MicroSADIC equipment and stored on magnetic tape. The tape is shown being removed from the MicroSADIC by Joseph Gianino, McDonnell's data reduction supervisor, who will then notify the IBM 709 computer operator by telephone that wind tunnel test data are ready. The 709 operator hits the interrupt button on the computer, and whatever is in progress is dumped onto a storage tape to be finished later. *(Continued)*



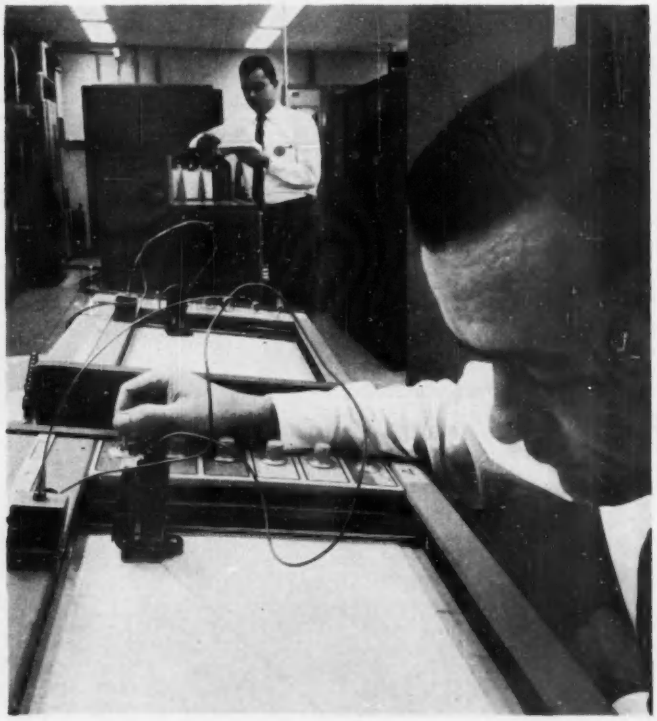


3.

The MicroSADIC tape is placed on the 727 tape unit in the background and transmitted by this 9702 remote tape control unit over eight twisted pairs of direct wire lines to a 9701 local tape control unit in the computer room, 12,200 ft away. By pressing the "transmit" button as shown, the tape runs as the 709 calls for it.

4.

At the computer room the 709 goes to work on the test data. Actual computer processing time for a wind tunnel test is 2½ min at the most and usually much shorter. The computer produces two magnetic tapes at high speed and is then put immediately back to work on the interrupted problem. One tape is read off-line into a 720A printer to produce the printed tabulation of the reduced data for inclusion in the engineering report on the test run. The other tape is immediately retransmitted to the wind tunnel via the direct wire link.



5.

Back at the wind tunnel, the incoming information is plotted directly on six Electronic Associates PACE Variplotters as six different segments of the reduced data. On a typical force test, three forces and three moments are measured. The six plotters permit simultaneous plotting for each of the parameters at a specific angle of attack. Since 300 points are often measured on a major long-run test (1,800 components), mass plotting is a real timesaver. The plotting is the slowest part of the operation and is done off-line as far as the computer is concerned. The 722 card punch in the background cuts the data into punched cards.

REPUBLIC VECTOR CONTROLLERS FEATURE 2 TO 500% PROPORTIONAL BAND ADJUSTMENT

Rockwell-Built Republic vector controllers feature easy proportional band adjustment from 2 to 500%, an adjustable reset rate from 0.1 to 50 repeats per minute and less than 0.05% dead band.

This is typical of the performance of Republic's new Null-Balance-Vector line of pneumatic instruments which includes:

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- Relays which extract square root down to 10% of output span.
- Multiplying, squaring, additive, totalizing, and ratio relays.
- Other instruments necessary for measuring, controlling, and computing variables for combustion and process industries.

The span ("K") of each Republic Null-Balance-Vector instrument can be easily varied by loosening the lock-screw and sliding the weighbeam assembly along the slot as shown in the schematic. Zero does not have to be reset and only a comparison reference is required.

A common component, containing the "K" adjustment as illustrated, is the base around which each Republic Null-Balance-Vector instrument is built. This common "heart" means that you have interchangeability of parts—even among instruments performing different functions. Conversion and replacement parts can be pooled instead of stocking spare instruments for each control function.

In addition, you benefit from simplified operating and maintenance training because the same principle of operation is used for all instruments. All Republic Vector instruments are compact, lightweight and rugged. The Republic Engineer in your area will be glad to work with you on any control or measurement application. Or, write for information to Republic Flow Meters Company, Subsidiary of Rockwell Manufacturing Company, 2240 Diversey Parkway, Chicago 47, Illinois. In Canada: Republic Flow Meters Canada Ltd., Toronto.

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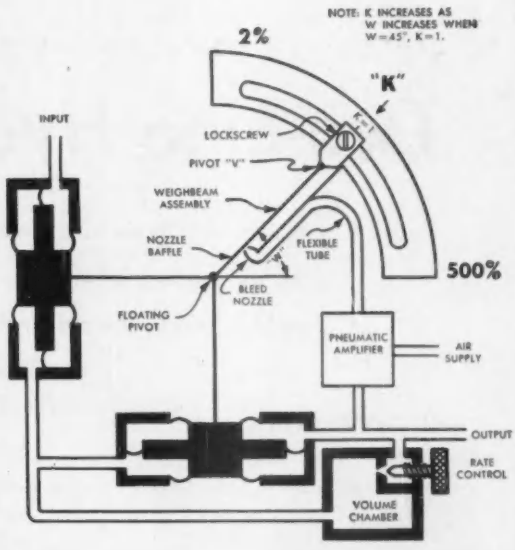
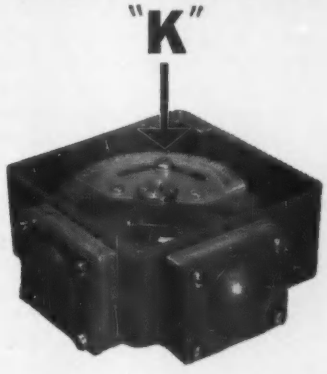
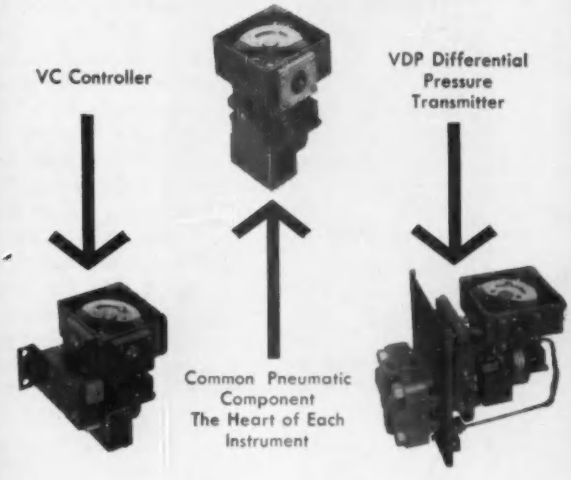




This is the common component around which each Republic Null-Balance-Vector pneumatic instrument is built. This component contains the "K" adjustment.

TYPICAL REPUBLIC NULL-BALANCE-VECTOR INSTRUMENTS



Two-Line Hydraulic Diagrams

- simplify synthesis and analysis of hydraulic systems
- simplify mating of hydraulic and electric controls
- simplify design layout and drafting

GEORGE STELMACH
Foundry and Mill Machinery Div.
Blaw-Knox Co.

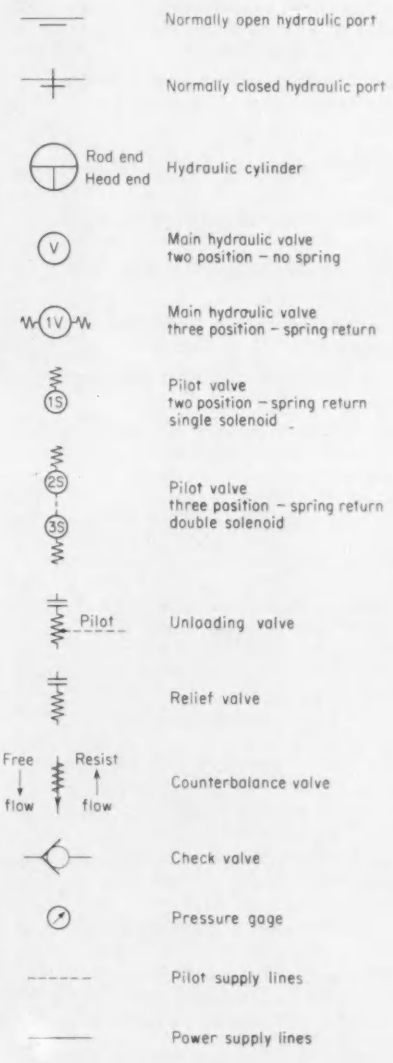
The usual ways of representing hydraulic control systems (including the JIC Standards) depict the system elements pictorially rather than functionally. This is satisfactory for simple systems but makes synthesis and analysis difficult and drawing preparation time consuming as systems get more complex. Similar problems would be encountered in electrical systems if the functional elements that make up the various control components were grouped in the electrical diagram as they are physically grouped on the components.

As an alternate and improved approach the author suggests representing hydraulic systems by "two-line" hydraulic diagrams analogous to two-line electrical schematic diagrams, where in the hydraulic diagrams one line represents supply pressure and the other return to tank. This yields a hydraulic diagram that looks like an electrical schematic and requires the introduction of new symbols that display hydraulic control elements by their individual system function rather than assembled in conventional component configurations. The proposed symbols are defined in Figure 1. Note the similarity between the symbols for normally open and normally closed hydraulic ports and the usual symbols for normally open and normally closed electrical relay contacts.

As hydraulic systems are called upon to perform an increased number of interlocking and logical control functions, this new display technique will make it simpler to synthesize and analyze the systems. In particular it will be useful when electrical engineers, used to thinking in terms of electrical schematics, are called upon to mate electrical and hydraulic elements in multimedium control systems and when future developments bring forth more complex multiport, multistage, and multispool valves.

Learning and making maximum use of this new display technique will require some reorientation. Five examples are given that contrast equivalent conventional and two-line diagrams. The first four show the conversion from conventional hydraulic system diagrams to two-line diagrams, while the last example converts from two-line to conventional diagram. One

FIG.1 THESE SYMBOLS ARE PROPOSED. THEY REPRESENT SYSTEM FUNCTIONS, NOT PIECES OF HARDWARE

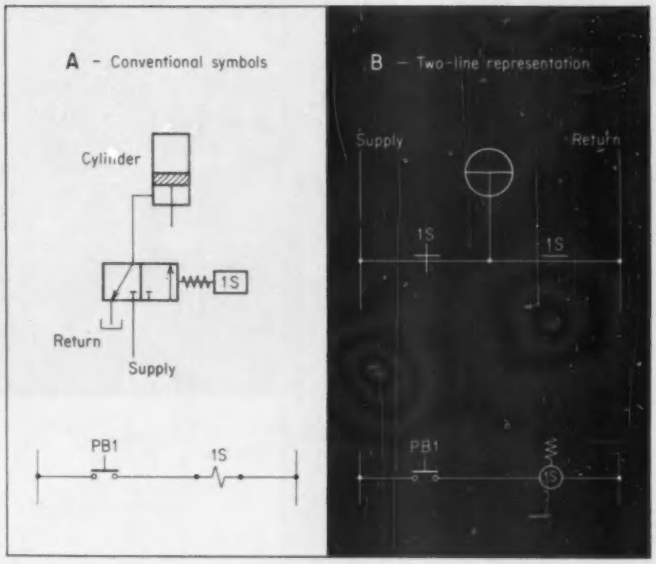


important rule is obvious from these examples: *the number of ports required to represent each valve in the form of a two-line diagram is equal to the number of "directions" of the valve, expressed in conventional symbols by the number of directional arrows.* Thus a four-way valve requires four port symbols on a two-line diagram. (The tandem-center valve in Figure 5 is considered to be a five-direction valve.)

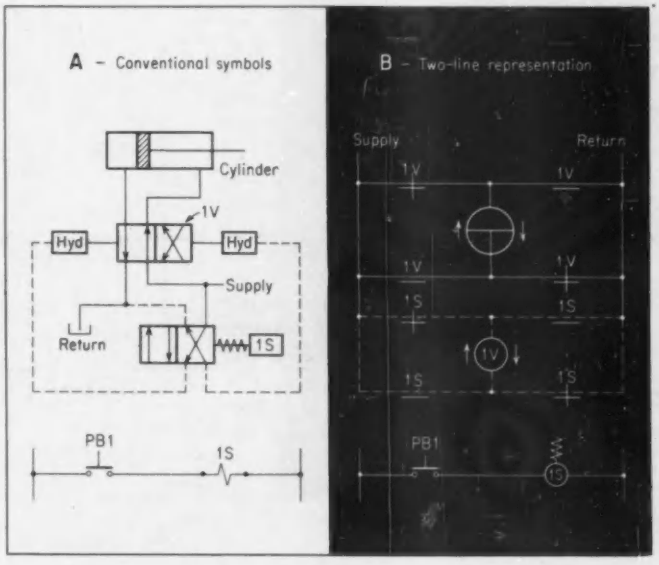
Note that very similar symbols could be used to form two-line pneumatic diagrams, a likely step in view of the interest in pneumatic logic elements.

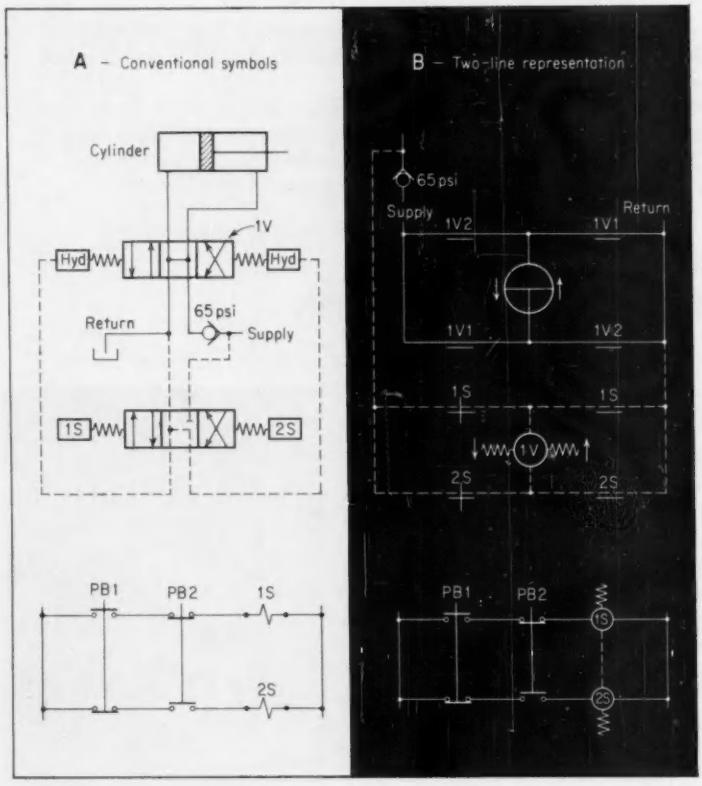
FOUR EXAMPLES SHOW CONVERSION FROM CONVENTONAL TO TWO-LINE DIAGRAMS

2.
The system shown in A consists of a cylinder and a single solenoid, two-position, direct operated, spring return valve. The supply port is blocked and the rod end of the cylinder is open to drain when solenoid 1S is deenergized. When 1S is energized, the piston moves up. In the two-line diagram of B the valve is split up into its functions of a normally open and normally closed port, each labeled by its actuating element, solenoid 1S. System function is identical, but note the ease of representation and understanding. The use of the new symbol in the electrical circuit diagram at the bottom clearly identifies the function of solenoid 1S.



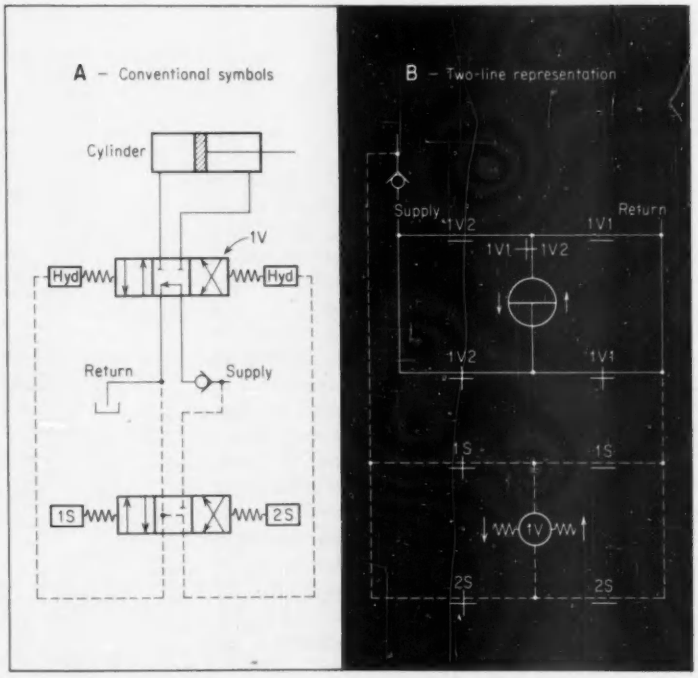
3.
In A is shown the conventional diagram for a system including a cylinder and a single solenoid, two-position, four-way, pilot operated valve. When solenoid 1S is energized, the piston moves to the right; when deenergized, it moves to the left. The pilot stage is represented by two normally open and two normally closed ports, each labelled 1S since they are actuated by solenoid 1S. In turn the main valve is represented by four ports, each actuated by the pilot stage. Energizing solenoid 1S actuates the 1S ports which energize the pilot stage to actuate the main valve 1V ports. As a general rule the direction of power flow through the main valve will agree with the direction of power flow in the cylinder as indicated by the arrows. This diagram looks as if it represents a control relay driving a power relay.





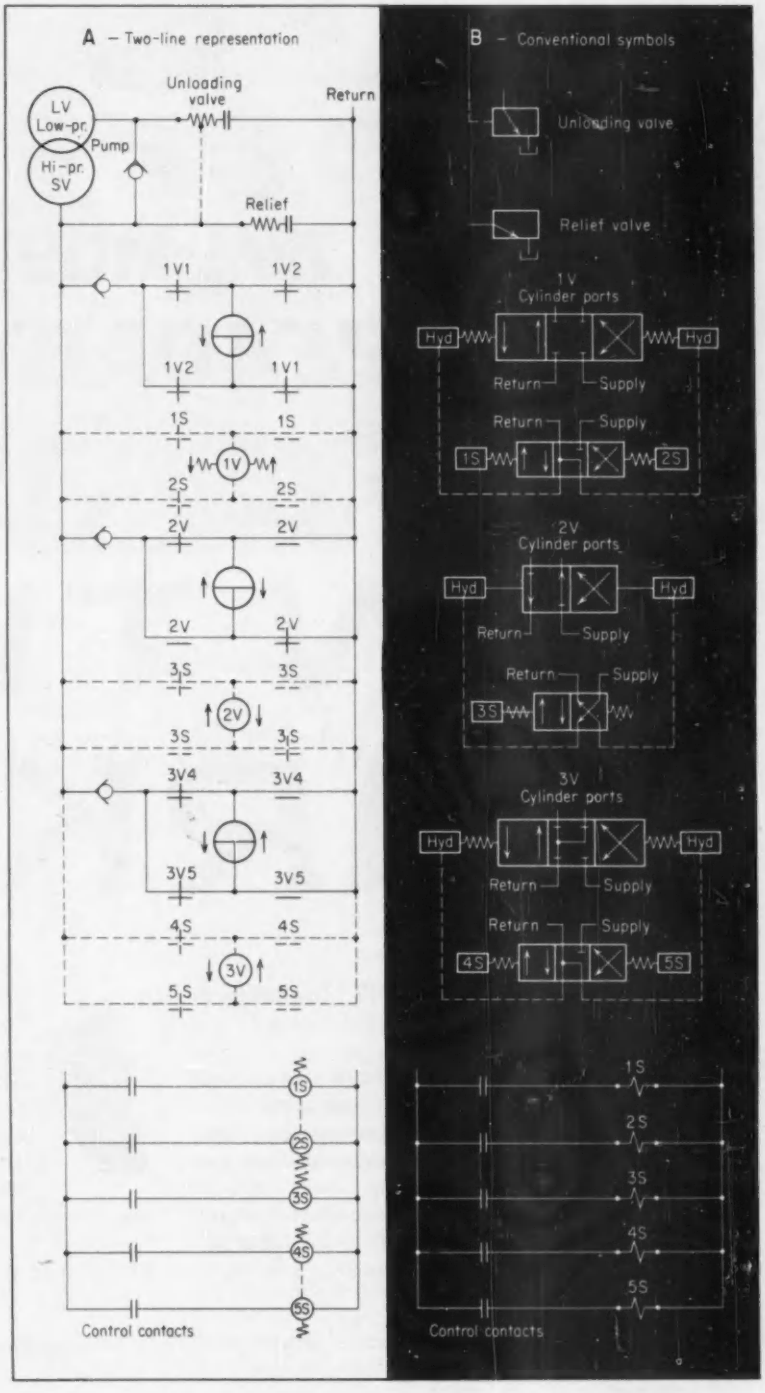
4.
Here the main valve is a four-way, three-position, spring centered, open center, pilot operated valve, while the pilot valve is a four-way, three-position, spring centered, double solenoid valve. The two-line diagram is similar to that of Figure 3. The principal difference is that the main valve is represented by four normally open ports characterizing its open-center nature, in that supply is open to return whenever neither pilot solenoid is energized. The spring-loaded check valve maintains 65 psi supply pressure at all times so that pilot pressure is available. In addition, the centering springs are shown on the main valve and the double solenoids and centering springs, on the pilot stage.

5.
This system is identical to that shown in Figure 4 except that this time the main valve is a tandem center, "five-way" valve. When neither solenoid is energized, the rod end of the cylinder is blocked by the two normally closed ports 1V1 and 1V2, and the head end of the cylinder is blocked by one normally closed port with the double index 1V1-1V2. The double index indicates that this port will open when either 1S or 2S is energized. With both solenoids deenergized, supply connects directly to return through the two normally open ports 1V1 and 1V2. This fairly complex hydraulic valving arrangement is easily visualized by means of the two-line diagram.



ONE EXAMPLE SHOWS CONVERSION FROM TWO-LINE TO CONVENTIONAL DIAGRAM

6.
This system, represented initially by a two-line diagram, consists of three hydraulic cylinders driven by a double pump unit. The double pressure, constant delivery pump was selected because the system is of the closed-center type. The large volume, low pressure pump (LV) is controlled by an unloading valve and provides fast cylinder motion during active portions of the cycle, while the small volume, high pressure pump (SV) is controlled by a relief valve and acts to minimize heat generation during holding portions of the cycle. The conventional valve types are recognizable from the two-line diagram. The four normally closed ports of valve 1V indicate that this is a four-way, three-position, closed center unit. The diagonally opposed normally open and normally closed ports of 2V identify it as a two-position, four-way valve. The two normally closed ports on the supply side and two normally open ports on the return side of 3V show it to be a four-way, three position valve with both ends of the cylinder connected to the return in the center position. The conventional diagrams show the same valve functions except that the interconnecting hydraulic lines are omitted for simplicity.



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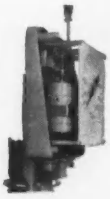

Other features of the 210T TRANSCOPE Transmitter include the weatherproof case which is split diagonally to make adjustments easily accessible. Single package pneumatics, encapsulated movements and actuating element are easily removed and replaced for on-the-job maintenance. Designed for Gage Pressure, Volumetric Pressure, Volumetric Load and Temperature. Non-indicating model (211T) also available.

Ask your Taylor Field Engineer or write for **Bulletin 98385.** *Taylor Instrument Companies, Rochester, N.Y., or Toronto, Ont.*

Taylor Instruments MEAN ACCURACY FIRST

FIG. 1. Manufacturing machine has multiple tool head (at left) milling spindle (in rear) and turret drilling spindle (at right). Hughes has now replaced the drill turret with a fourteen tool boring spindle. Tape control and electronic logic units are in cabinets at far left.

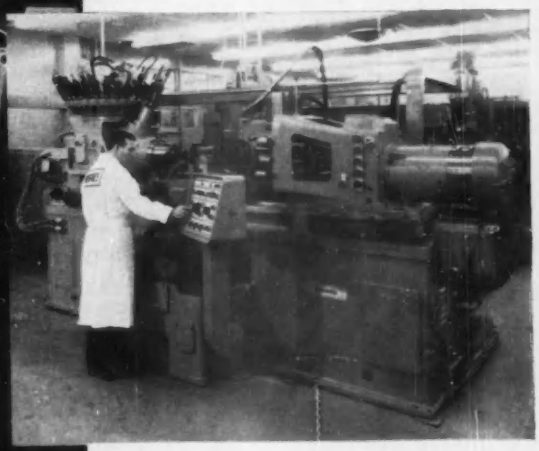

FIG. 2. Closeup of machining heads with manual input pedestal in foreground.

Three-Axis Tape Control Runs Manufacturing Machine

MICHAEL MURPHY
McGraw-Hill News

Numerical control directs a new, unusual three-headed machine tool that can mill, drill, ream, tap, and bore.

The machine tool pictured above represents the newest concept in metalworking: it is a manufacturing machine, numerically controlled, with three machining heads so it can mill, drill, ream, tap, and bore. Called the MT-3 Machining Center by its designer Hughes Aircraft Co., Industrial Systems Div., it has a punched tape, three-axis control system to direct a two-axis positioning table and three traveling spindles (one in each machining head).

In its initial configuration the flexible MT-3 system clusters three traveling machining heads about a single automatic indexing and positioning table. The first head is the most flexible because it contains an automatic tool changer system that holds up to 30 tools and can change tools in 3 sec. The second head has an 8-in. diameter capacity milling spindle for heavy milling cuts over a 24-in. horizontal travel. In the third head is a 6-in. capacity spindle for precision boring operations. An automatic tool changing magazine holds 14 pre-set boring bars.

The control directs all three head motions through two logic units (Figure 3): an electronic working

storage and a relay working storage. Electronic working storage monitors movement of the two-axis positioning table and three traveling spindles. Dimensional information is received from a buffer circuit and compared with incremental positioning and velocity feedback data from the hydraulically powered machine tool.

The relay working storage routes all auxiliary data to the machine tool including automatic spindle selection, automatic tool selection and tool change, and spindle feeds and speeds. Positioning and stop signals from the electronic working storage are transmitted through the relay working storage to a hydraulic servosystem.

Each axis control contains two registers. The buffer register receives information from the tape reader. Upon command, the information is transferred from the first register to a working register. The dual units make possible extremely flexible axis movement including a rapid initial approach to a desired position, a slower speed approaching coincidence, and a final creep stage to target. The counters also provide visual readout for maintenance purposes.

Positioning information is fed back to the electronic working storage by electromagnetic transducers attached to recirculating ball leadscrews, Figure 4. As a small spiral gear affixed to the leadscrew revolves in the transducer, a stationary, variable reluctance type of pickup senses the air gap and no-air gap created by each land and groove of the spinning gear. A second similar pickup supplies directional information, and a tachometer provides velocity feedback information.

Tool storage on the most flexible head of the machine is provided by a rotating magazine equipped with 30 tool holding pockets. The tool magazine holds tools up to 3½ in. in diameter. Each pocket is identified by a binary code that is pre-set on mechanical cams. Tool selection is accomplished by tape commands that position the rotating magazine so that the tool may be lifted from storage and inserted into the ready spindle. A hydraulically-operated ram moves the tool. In a similar manner, tools are removed from the ready spindle and returned to the magazine. Tool search is conducted in parallel with machining operations. At the end of an operation, the dual spindle mount rotates 180 degrees in three seconds to bring the new tool into working position.

In other words, the tool moves first from the tool magazine to a ready spindle, and then is rotated into cutting position.

The change is fast enough, says MT-3 Project Engineer Gene Rector, to allow multiple operations at a single location. For example, drilling and reaming operations can be performed on a series of holes by rotating the dual spindle at each location, rather than by drilling all the holes and then reaming all of them. This serves to improve the accuracy as well as reducing the total cycle time.

Because unidentified tools are inserted into preselected coded tool pockets, the Hughes system does not need a large inventory of coded tool holders.

Hughes powers its multipurpose number one head with a 5-hp spindle drive through a speed range of 40-4,000 rpm in 28 steps. Feed speeds range from 1 to 75 in. per min in 31 steps. The head has a maximum travel range of 19 in., a rapid traverse rate of 150 ft per min.

The heavy milling head is driven by a 10-hp spindle drive through a speed range of 60 to 2,400 rpm in 28 steps. Its horizontal travel range is 24 in. A 15-hp spindle drive also powers the precision boring head, but through a speed range of 100 to 3,000 rpm in 21 steps. This head has a 19-in. maximum travel range and a traverse of 75 ft per min.

Mounted atop the positioning slide, the machine's

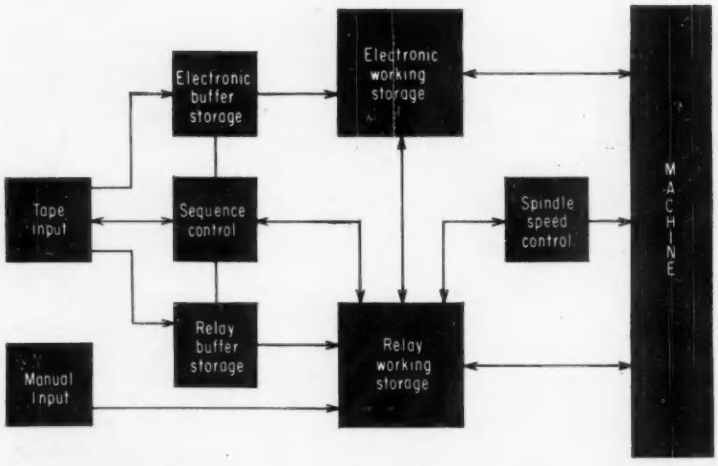

FIG. 3.
Diagram of controls for three machining heads. Tape and manual instructions feed two logic units. Electronic working storage monitors movements; relay working storage routes auxiliary data to the tool.

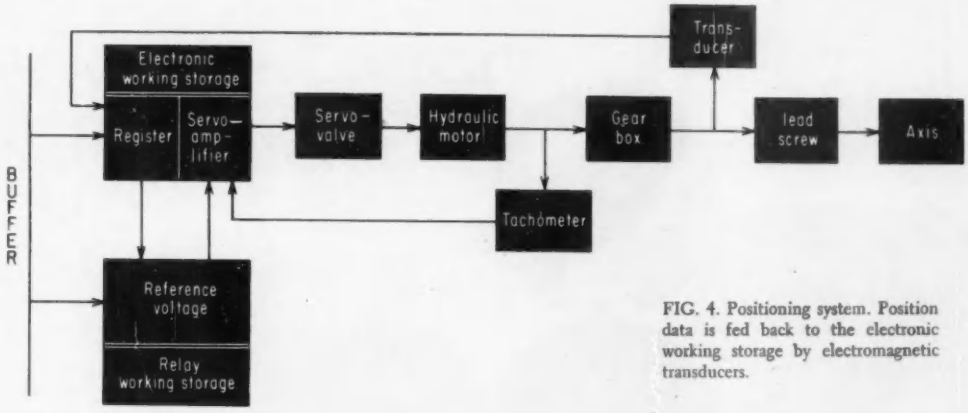

FIG. 4. Positioning system. Position data is fed back to the electronic working storage by electromagnetic transducers.

rapid indexing table permits two directional 180-deg part rotation in 16 steps of 30 and 45 deg. The positioning table has a 24-in. traverse and 12-in. vertical travel range.

In addition to rapid traverse rates, the positioning slide and table can both be moved under feed-rate control with the same ranges of one to 75 in. per min. This provides the added capability of milling with vertical feed of the work piece; machining slots; or performing any operation with milling cutters performing with milling cutters any operation that can be done by movement in any one of the three orthoganal axes. System resolution is 0.001 in.; overall accuracy is plus or minus 0.0008 in. with a repeatability of plus or minus 0.0003 in.

Designed for job shops

Behind the MT-3 system is Hughes' belief "that a truly versatile, efficient, manufacturing machine *cannot* be designed around a single spindle concept."

This is why Hughes decided to design separate heavy milling and precision boring heads. "Since the system has been designed primarily for job shop operation, beefing up a single spindle machine, simply to handle larger milling and boring cuts, turns away many job lot manufacturers who don't need this increased capability," says Hughes Sales Manager George Kinny.

The MT-3 concept is a direct outgrowth of an earlier, ill-fated Hughes venture into machine tool control. In the spring of 1958, in a joint effort with machine tool builder Kearney & Trecker, Hughes applied a "Digitape" punched tape control system to a line of three different K&T machine tools—a milling machine, a drilling machine, and a boring machine—interconnected by an automatic transfer mechanism. The line could be programmed to perform successive machining operations on a single part or machine several parts simultaneously. Although the system was a superb engineering breakthrough, it turned out to be difficult to market because of the high price of the machine tool line—approximately $125,000 per machine. And fabricators were reluctant to commit their manufacturing operations to a single automatic line. The transfer line is in use today in the Hughes El Segundo Manufacturing facility. The company claims the line—the only numerically controlled transfer line ever built—has paid for itself out of savings.

Kearney & Trecker, in further efforts of its own, modified the system, and came up with the phenomenally successful Milwaukee-Matic "manufacturing machine" (CtE, March '59, p. 27). Now, Hughes with its revitalized approach hopes for similar success with the MT-3 "machining center".

As a starter Hughes plans to offer three different combinations. It will package a single head machine, complete with a 30-tool storage magazine and a high speed automatic tool changer, for $127,000. The two-headed machine, with the heavy milling capability added, will sell for $135,000. A complete three-head system, which includes the heavy boring spindle, is priced at $155,000.

Chief marketing targets for the manufacturing type machines are job lot manufacturing concerns —the tools are definitely not tailored to mass production industries. Typical prospects for these numerically controlled centers include the aircraft and missile industry, the machine tool industry, special machinery builders, and control makers.

Prime parts to be machined on the MT-3, according to Hughes, would normally have three or more holes to be drilled and one or more surfaces to be milled. Biggest savings come from reduced tooling cost, higher tool engagement time, and optimization of the machining process.

A West German machine tool builder, Berkhard and Weber KG built the first machine to accommodate a workpiece up to a 12-in. cube. It can actually accommodate work 12 x 12 x 24 in. Next models will be able to handle an 18-in. cube. Hughes has no plans to build the machine itself. The company will soon ask American tool builders to bid on MT-3 hardware contracts. It wants a good multiple source if MT-3 orders materialize faster than expected.

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Gas Diodes Indicate and Remember

GLEN W. KREBS, Assembly Products, Inc.

A pressure monitoring system currently being installed is based upon an interesting dual use of a simple cold cathode gas diode as an indicator and data storage device. Since the completed system requires that almost 700 points be measured, a scanning technique had to be employed to keep down the number of measuring circuits because of their cost. In this system 25 monitoring panels capable of measuring 30 points each and costing slightly more than $2,000 each will be installed in various locations. Each point is scanned once every 5 sec.

Each monitoring panel, Figure 1, includes a scanning commutator, a measuring bridge circuit with two high and low contact meter relays, and a 4 x 30 matrix of cold cathode gas diodes. Pressure measurements are brought into the monitoring panel by low cost telephone lines from remote points. The monitoring panel indicates and alarms for four abnormal conditions at each point: high pressure, low pressure, telephone line open, and telephone line shorted. Once a fault is indicated on any scan, the gas diode indicates it continuously until it is reset by the operator.

Figure 2 is a simplified diagram of the monitor system. The only equipment at each remote measuring point is two pressure limit switches, each shunted by a resistor. The resistors is two pressure limit switches, each pressure limit switch is normally open and the low pressure switch is normally closed. A third resistor in series makes the total resistance 25,000 ohms when the pressure is high, 50,000 ohms when it is normal, and 75,000 ohms when it is low.

The resistance network at each measuring point is made part of the measuring bridge at the monitoring panel once during each revolution of the commutator. The bridge is balanced for the normal resistance of 50,000 ohms and supplies no voltage to the two series-connected zero-center relay meters. If the bridge is unbalanced by a high or low pressure or by a shorted or open telephone line, then one of the two relay meters will make a contact to operate one of the four load relays. This will fire one of the gas diodes to indicate the fault and will also sound an alarm.

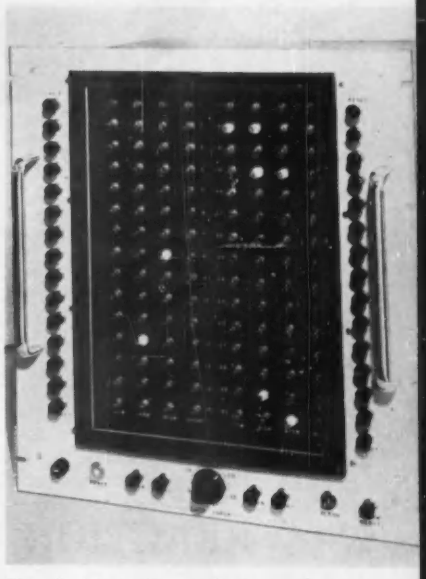


FIG. 1—Monitoring panel scans and measures pressures at 30 remote points. Cold cathode gas diodes act as fault indication and once fired remain on until reset by operator.

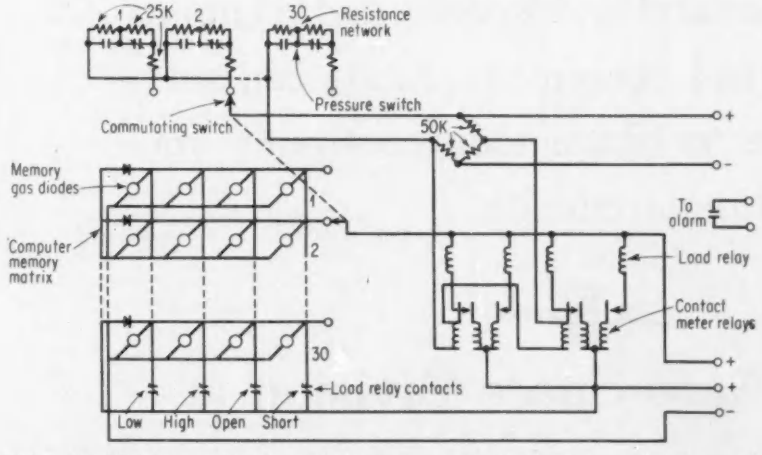
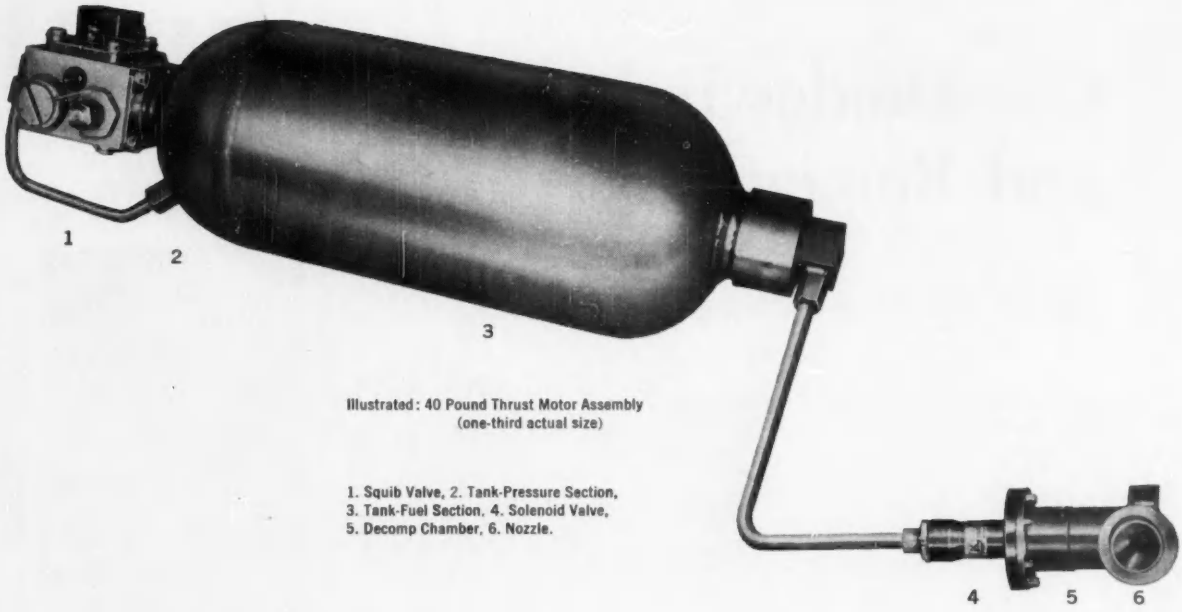


FIG. 2. Simplified diagram shows how resistance-type measuring circuits are scanned simultaneously with matrix of gas diodes. Meter relays operate load relays that inhibit firing of diodes.

The pointer of the high and low pressure indicating relay meter moves a short distance either way from center to make its contacts. The pointer on the short or open indicating relay meter must move farther. To prevent a false indication of high or low pressure when there is a short or open line condition, the pressure indicating meter pointer is damped to move much more slowly than the line condition meter pointer. Thus if the resistance change is great enough to indicate a line fault, the fast moving pointer will make its contact before the pressure indicating relay can give a false indication. To prevent a double indication in this case, back contacts on the short or open load relays operate to shunt the load contacts on the high and low relays respectively. If the resistance change is small enough to indicate high or low pressure only, contact on the second meter is not possible.

Figure 3 shows the circuit used for each cold cathode gas diode in the matrix. The load relay contact is normally closed as shown. If the memory diode is not conducting, the highest voltage that can appear at its anode is the holding voltage (+) be-



Illustrated: 40 Pound Thrust Motor Assembly
(one-third actual size)

1. Squib Valve, 2. Tank-Pressure Section,
3. Tank-Fuel Section, 4. Solenoid Valve,
5. Decomp Chamber, 6. Nozzle.

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cause the clamping diode D_1 conducts as the voltage tries to rise higher when the commutating switch is closed. But if the load relay contact is opened by a fault indication, the voltage at the anode can rise toward the firing voltage supply (+ +) and the memory diode will turn on. When the memory diode is conducting it is held on by the holding voltage (+) through diode D_2 and the resistor, and it can only be extinguished by depressing the reset button to remove the hold voltage.

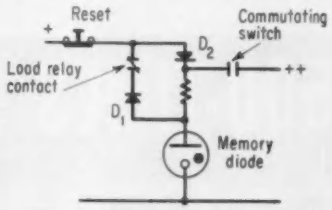


FIG. 3. Circuit used for each gas diode in matrix of Figure 2.

Three Magnets Make Simple Linear to Rotary Converter

JOHN J. DIETZ
Thomas A. Edison Industries, McGraw-Edison Co.

Figure 1 shows how three small disc-shaped permanent magnets can be used to construct a direct reading pressure transducer. The magnets are charged diagonally across their faces as shown. Magnet A is fixed so that it cannot move. Magnet B is moved by the pressure sensitive bellows and can translate only along the axis x—x'. Magnet C is bearing mounted to rotate about x—x' but cannot translate.

If the poles of magnets A and B are displaced at a fixed angle of 180 deg, magnet C will find an angular position somewhere in between that depends upon its axial position in the space between magnets A and B. Thus magnet C will rotate about x—x' as the distance *ds* varies with bellows displacement.

Figure 2 shows the empirical relationship between the angular position of the rotor magnet C and the displacement of magnet B for the experimental device shown in Figure 3. For these tests the distance between A and C was fixed at 0.018 in., and ds was varied between 0.002 and 0.028 in. The test rig was not optimized and employed three Alnico II magnets each $\frac{3}{8}$ in. in diameter and $\frac{1}{8}$ in. thick. The assembly produced a torque of 14 gm-cm at 100 deg of rotation. Considering the 9-gm weight of the rotor assembly C, the torque to weight ratio of 1.5 gm-cm per gm indicates excellent instrument sensitivity with the magnet spacings stated.

As might be expected, $d\theta/ds$ is maximum when the rotor is centered between the end magnets and the mid-range linearity is quite good. Other magnet spacings produce similar results, and $d\theta/ds$ varied inversely with the gap size. Higher values of $d\theta/ds$ can be produced by coupling the two end magnets and translating them simultaneously with respect to the rotor. An interesting test conducted on the model has shown that angular rotations beyond 180 deg are possible, but linearity decreases and the system becomes unstable at around 250 deg.

Possible applications

The motion converter described has a number of practical possibilities:

- High accuracy pressure indicating instruments based on the principle of Figure 1, with a means added for damping the rotor.
- In its more generalized form, with both end magnets driven axially by bellows on diaphragm, as a simple servo null detector.
- Direct reading surface temperature indicators; both end magnets are fixed but one is made of a temperature sensitive magnetic shunt material.

Any of these instruments can be made into electrical transducers by having the rotor drive a small, low torque potentiometer.

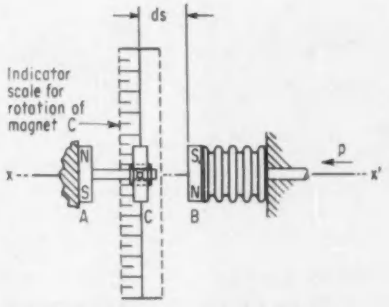


FIG. 1. Changing magnetic field distribution as spacing between magnets A and B varies causes magnet C to rotate in this simple linear to rotary motion converter.

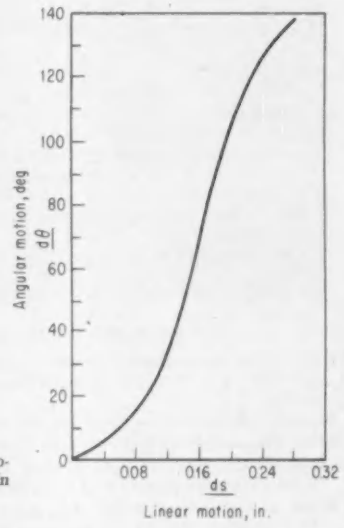


FIG. 2. Linearity of linear to rotary motion conversion is quite good in mid-range.

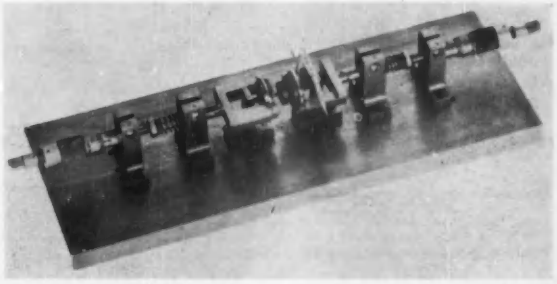


FIG. 3. Test rig from which experimental data were taken.

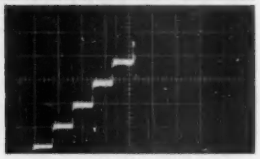
500-TIMES MAGNIFICATION–VERTICALLY

...for detailed waveform analysis

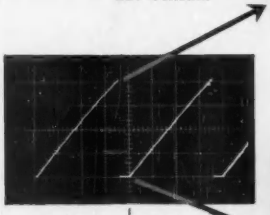
Waveform Details of a 100-v Staircase

Vertical Expansion 500 Times

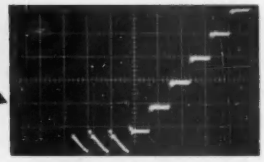
Horizontal Expansion 500 Times



Vertical	Horizontal
50 mv/cm	10 μsec/cm
$V_C = +92.5$	



Vertical	Horizontal
25 v/cm	5 ms/cm
$V_C = 0$	



Vertical	Horizontal
50 mv/cm	10 μsec/cm
$V_C = -5.5$	

TYPICAL APPLICATIONS

FAST-RECOVERY AMPLIFIER—observe small signals riding with large gates.

MODULATION MONITOR—measure amplitude modulation on a digital train pulse.

HIGH-AMPLITUDE HUM REJECTION—reject up to 200 volts peak-to-peak common-mode hum.

SEMICONDUCTOR CHARACTERISTICS—measure Zener diode ac impedance and Zener voltage together, measure transistor output impedance.

PULSE-HEIGHT ANALYSIS—select any pulse above a preset dc level.

COMPONENT MATCHING—check components to easily-interpreted tolerances.

MAIN CHARACTERISTICS

3 Modes of Operation—as a conventional preamplifier, as a differential-input preamplifier, or as a calibrated differential comparator.

50-mv/cm Sensitivity—nine calibrated attenuation steps to 25 v/cm.

Wide Passband—dc to 13 mc with Tektronix fast-rise scopes.

±100-volt Dynamic Range—permits common-mode signals up to 100 volts to be applied to the unit without attenuation.

40,000 to 1 Common-mode Rejection Ratio—allows measurement of differential signals less than 50 millivolts.

Comparison Voltage Accuracy—within 0.25% on the ±1-volt scale; within 0.20% on the ±10-volt scale; within 0.15% on the ±100-volt scale.

Safety Feature—the Type Z eliminates "floating oscilloscope" operation.

AC and DC VTVM—extends oscilloscope accuracy in both ac and dc voltage measurements to 0.2%.

Price, Type Z Plug-in Unit, f.o.b. factory **$525**

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Simulation OKs C-Stellarator Power Supply Control System

J. R. HURLEY
Allis-Chalmers Mfg. Co.

The C-Stellarator is a large scale experiment designed to investigate hydrogen fusion processes and the properties of high temperature plasmas. Ionized gas or plasma at temperatures up to 100 million deg K will be confined in a racetrack-shaped tube by an axial magnetic field. The field coils require accurately controlled direct current up to 44,600 amp at 3,000 volts. High current densities are necessary in the coil conductors because intense magnetic fields are required to confine the plasma. Intermittent pulsed operation is therefore employed to prevent thermal damage to the water cooled windings.

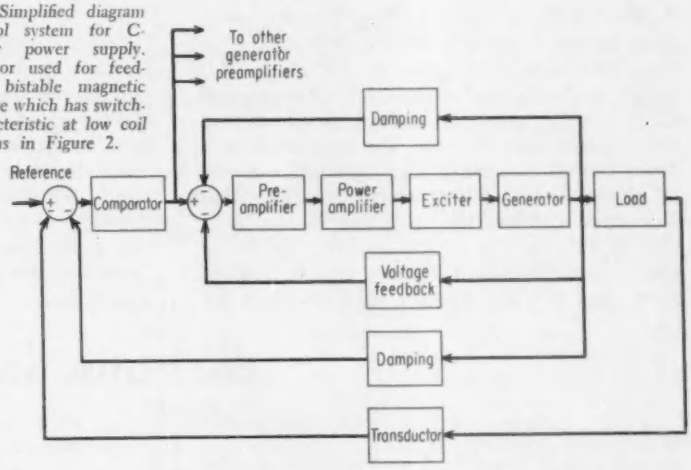
The control system must regulate the current to plus or minus 1 percent. Basically the main loop of the control system consists of a comparator and two cascaded magnetic amplifiers driving an exciter which in turn controls the generators, Figure 1.

The confining field coil is powered by eight generators, each of which has its individual magnetic preamplifier, power amplifier, and exciter. A common comparator drives the eight preamplifiers.

During the time between pulses, the dc power supply must control the current to less than 100 amp per generator. The residual voltage of the generator and the switching effect of the transductor tend to make the zero current regulation difficult.

A high-gain control system will minimize the effects of the dc machine residuals, but the transductor switching could introduce oscillations exceeding the amplitude allowable.

FIG. 1. Simplified diagram of control system for C-Stellarator power supply. Transductor used for feedback is bistable magnetic core device which has switching characteristic at low coil currents as in Figure 2.



A transductor is a dc current transformer in which the output current is inherently proportional to the magnitude of the current being measured. A transductor therefore normally has a V-type input-output characteristic. A saturated transistor flip-flop discriminator is used with the transductor on the C-Stellarator which switches over near zero bus current and makes it possible to get the push-pull action shown from a single transductor. The discriminator is actually responsible for the switching dead space in Figure 2.

The output signal of the transductor thus cannot represent currents lying in the dead range of minus 35 to plus 35 amp. When the measured current lies within this range, the output corresponds to either plus 35 or minus 35 amp depending on whether the current entered the dead range from the positive or the negative.

The control system with several simplifying changes was simulated on a PACE electronic analog computer to determine if the accuracy requirements could be met. Figure 3 shows the response of the simulated system to reference inputs corresponding to output currents of 60, 20 and 0 amp. The response at 60 amp was smooth since the control point was outside the unstable range of the transductor. But oscillations occurred for the 20-amp control point.

As the reference signal was decreased to zero, the frequency of the oscillation increased and the waveform of the oscillations gradually become symmetrical. The maximum amplitude of oscillation was less than 50 amp for operation in this region, so the simulation checks out the control system design.

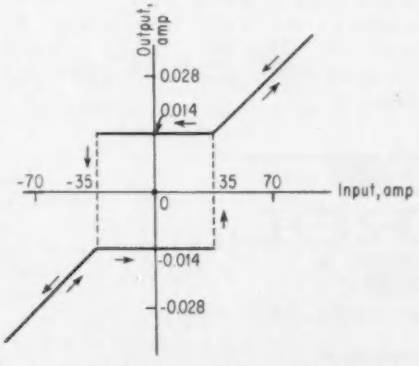


FIG. 2. Switching characteristic transductor which raised question on stability of system in Figure 1.

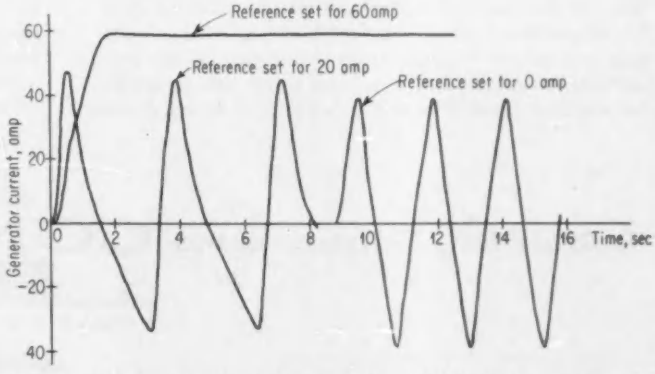
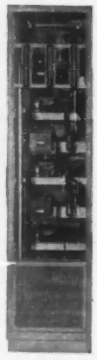


FIG. 3. Simulation of system in Figure 1 showed instability for small currents, but oscillation amplitudes were within idling current limits of power generators.

JOURNAL OF APPLIED CONTROL DEVICES THAT NEVER WEAR OUT

For Control Engineers Who Are Wearing Out Before Their Time

FREEZING A MOLTEN WILL-O'-THE-WISP (to ±¼° at 2200°F)



Pittsburgh Plate Glass Company freezes molten glass temperatures at 2200°F to within ±¼° as it extrudes fiber glass so fine that 1700 miles of it weigh but one pound! How? PPG has selected CPM-1 Temperature Controllers made by Hagan Chemicals & Controls, Inc. The Hagan systems (over 200 of them have been ordered) not only set a new order of uniformity for glass fiber diameters, but are virtually wear-proof. They achieve this doubly profitable result by use of static control elements: there are no moving parts, and only one vacuum tube device in the entire system! An integral part of the CPM-1 unit is a CONTROL Proportioning Reactor with six control windings. It receives a proportional signal, a reset signal and a rate signal, and provides both current limiting and manual control. *"Rugged and able to handle multiple signals, yes," said Hagan engineers, "but what about sensitivity?" When we showed them the proportioning reactor's 2-milliampere windings, there were no more questions. However, we'll be happy to answer any you may have.*

Figure 1. Hagan CPM-1 Temperature Controllers. Square Boxes are CONTROL Proportioning Reactors.

ON YOUR BOBBIN, RESET, GO!

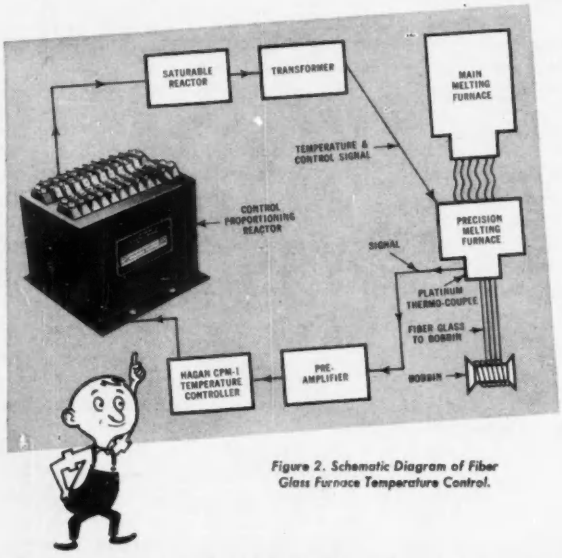


Figure 2. Schematic Diagram of Fiber Glass Furnace Temperature Control.

Fiber glass is pulled through a die in the bottom of a "bath tub" of molten glass at more than 3 miles per minute. It is wound on a bobbin, and when a "package" is completed, the operator has 15 seconds to change bobbins and restart the operation. There is as much as a 15° temperature upset in the system, yet when the winder restarts, the controller must reset the temperature at 2200° within ±¼° in the allotted 15 seconds. The CONTROL reactor puts out 100 watts at 80 volts, sufficient power to drive the saturable reactor ahead of it, and is at the instant beck and call of rapid and minute changes in signal. The response of the overall Hagan system is better than 0.1 seconds at full output. *When the first tests were run, accuracy of control was found to be even better than the ±¼° anticipated. Should you wish to learn more about these satisfactions with static control via our proportioning reactors, we'll be happy to answer your request for intimate details.*

STATIC CONTROL: (flexible and standard)

The function CONTROL Proportioning Reactors play in a system (the Hagan Temperature Controller is a telling example) is unique. The designer—for process control, for machine tool control, for assembly line control, for almost any control—can feed a variety of input signals into several isolated control windings in each proportioning reactor, and sum them to provide an amplified control signal. The reactor's figure of merit (ratio of volt-ampere amplification to time of response) is exceptional. It is as high as 1,500 for an N_C^2/R_C of 1,800. Thus, there is both power and sensitivity for the designer who works with static control. *Want to know who else among the nation's leaders have joined production-smart Pittsburgh Plate Glass in the swing to static control? We'll be happy to tell you—and to help with your static control ideas.*

Reliability begins with CONTROL®

A DIVISION OF MAGNETICS INC.

DEPT. CE-79. BUTLER, PENNSYLVANIA

A Unique Analog Analyzer for Nonlinear Systems

WILLIAM H. ALLISTON
Bettis Atomic Power Div.,
Westinghouse Electric Corp.

The describing function method is popular for analysis of nonlinear systems. In general it assumes that the nonlinear transfer function is separable into two parts: a nonlinear part which is real and dependent on the signal amplitude only and a linear, frequency dependent part. The assumption is usually valid in cases where the linear part of the system attenuates the harmonics generated in the nonlinear part enough to make them small compared to the fundamental. The describing function method measures the amplitude and phase of the fundamental component in the output with reference to the input sinusoid.

A nonlinear system analyzer has been developed which makes these measurements automatically for a wide range of frequencies and input amplitudes by solving for the coefficients of the fundamental terms in the Fourier expressions of the in-phase and quadrature components of the output waveform:

$$A_1 = \frac{1}{\pi}\int_0^{2\pi} E_o \sin \omega t \, d\omega t \qquad (1)$$

and $$B_1 = \frac{1}{\pi}\int_0^{2\pi} E_o \cos \omega t \, d\omega t \qquad (2)$$

The analyzer produces dc outputs proportional to these coefficients for input to the two axes of an automatic X-Y plotter. The result is a polar plot of amplitude at various phase angles, frequency varying along the locus.

Figure 1 is a block diagram of the analyzer, which was built of standard analog computer components except for the controller which times the integration. The analyzer solves Equations 1 and 2 simultaneously. The sine-cosine wave generator must supply two sine waves which are 90 deg apart in phase over a frequency range of, say, 0.001 to 20 cps. Several methods are available for generating these sine waves: the zero-damped-system analog oscillator was used in the initial model of the analyzer because of its simplicity. This oscillator is subject to some drift, although it can be stabilized. No stabilization was used, however.

The analyzer has two operating modes: continuous and discontinuous. Continuous operation is desirable because it provides a continuous plot. But a disadvantage is that no mark is made to identify frequency points on the plot. Also, since the analyzer was intended to operate with actual control systems which might involve frequencies as low as 0.01 cps, the integrating circuit must have a very long time constant. This leads to impractical slowness of operation in the low frequency range. Discontinuous operation overcomes these difficulties.

In the discontinuous mode the integration is done over one cycle of the input frequency only. A special timing circuit stops the integration. The integrator then holds whatever voltage it has accumulated until it can be plotted. An automatic pen-drop circuit makes the plot. The operator must then reset the integrator, make whatever changes he wishes in the frequency, and amplitude of the input from the signal generator, wait for the system transients to die out, and then restart the integrator.

As the frequency is increased, the integrators operate for a shorter and shorter time since one cycle of the frequency becomes shorter. The value of the integral would thus decrease with frequency, so compensation is provided by multiplying by a frequency proportional term before the integration. The equations also show the requirement for this multiplication, although it is not necessary in the continuous mode due to the continuous averaging process.

The discontinuous mode requires a controller to start the integrators at

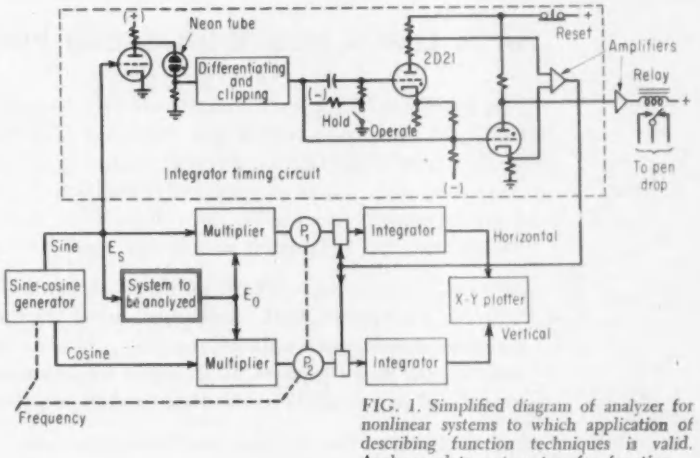


FIG. 1. Simplified diagram of analyzer for nonlinear systems to which application of describing function techniques is valid. Analyzer plots system transfer function.

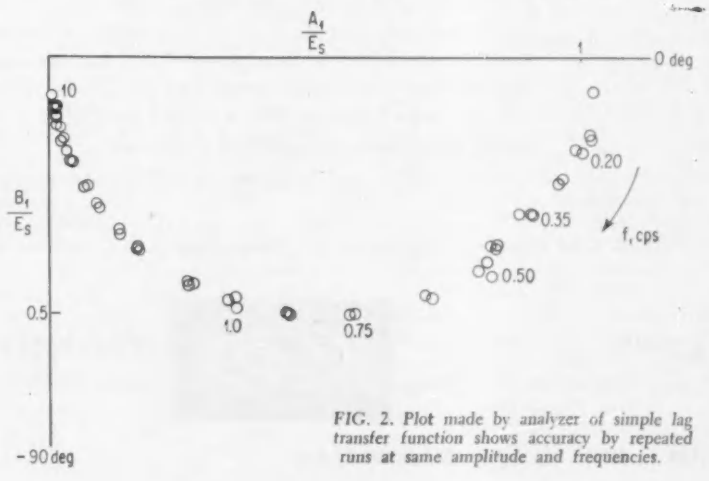
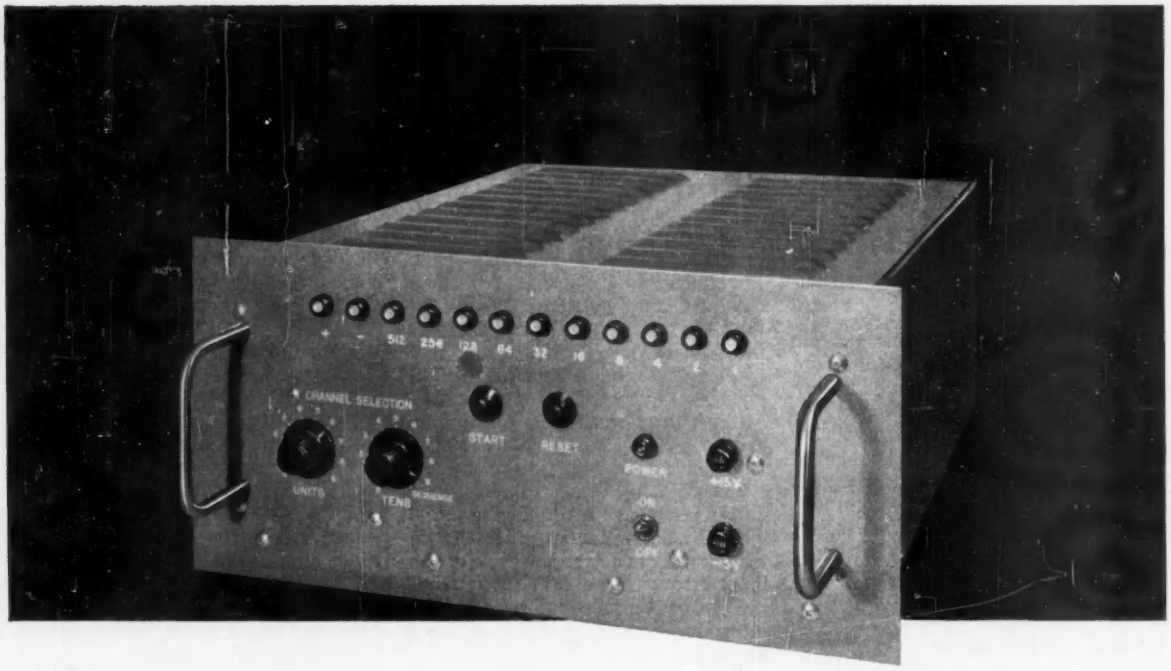


FIG. 2. Plot made by analyzer of simple lag transfer function shows accuracy by repeated runs at same amplitude and frequencies.



NOW...LOWER COST PER CONVERSION CHANNEL

WITH LINK'S NEW HIGH SPEED PRECISION MULTIPLEX CONVERTER

The Precision Multiplex Converter offers a high-speed voltage to digital conversion system that combines high speed performance with ultimate precision. This multi-channel Dialog* converter, with minimum physical dimensions, is completely transistorized to provide utmost reliability—a high-capacity multiplexer and conversion unit in one *small* package.

Advanced design concepts of the Precision Multiplex Converter include: **Automatic drift correction, solid state circuit design, integrated reference voltage supplies, incorporated visual display, no moving parts, high input impedance, unlimited modification possibilities, limited power requirements.**

Specifications of the Precision Multiplex Converter: • Input capacity from 1 to 500 channels • input voltage, 0 to ± 10 volts with higher voltages optional • conversion format 10 or 11 bits plus sign • conversion code—natural binary, binary coded decimal or excess three • conversion speed 5 μs per bit, 60 μs per channel • accuracy .05% • output parallel or serial, automatic or on external command.

Write to Dept. CE Dialog System Sales for specific details on the Precision Multiplex Converter and other Dialog systems and components.

**DIALOG (Link Digital—Analog Systems and Components)*

Another Example of Link/Ability

LINK DIVISION
Binghamton, New York

GENERAL PRECISION, INC.
Other Divisions: GPL, Kearfott, Librascope,

the beginning of a cycle and stop them at the end of the cycle. A neon tube coincidence circuit performs this function, although a more accurate system such as a multiar might be desirable in a final model of the analyzer. Note that the firing point of the coincidence circuit is not critical. It makes no difference when the integrators start and stop in the cycle as long as the operating time is equal to the period of the input wave.

The neon tube timer operates by generating a positive pulse once during each cycle of the input sine wave. Unless biased beyond cutoff because the hold-operate switch is open, the first 2D21 thyratron fires to provide a positive voltage to the clamping circuits and start the integrators. The firing of the first 2D21 also biases the grid of the second 2D21 so that the next pulse from the neon circuit will cause it to fire. This makes the clamp inputs negative again to stop the integrators. The plate voltage on the second 2D21 actuates the pen-drop relay to record the voltages accumulated on the integrators. The 2D21's cannot be fired again until plate voltages are momentarily removed.

Figure 2 illustrates the accuracy obtained when the analyzer was applied to a simple lag network. The closely grouped sets of points are repeated runs for the same amplitude and frequency. The percentage error compared to the signal amplitude changes very little. Its accuracy is comparable with that of an analog computer simulation of most real control systems—on the order of a few percent.

Two Stepping Motors Drive Tape In Versatile Transport

The magnetic tape transport mechansims built by Redifon Ltd. (Sussex, England) for use with its RADIC (Redifon Analog-Digital Computing system) is designed around a novel dual stepping motor drive that permits many unusual applications. The basic tape transport mechanism and its control system are diagrammed in Figure 1. The machine uses 35-mm magnetic tape with sprocket holes—like 35-mm photographic film. It can handle up to 1,000 ft of tape on reels or a continuous loop up to 40 in. long.

Conventional magnetic tape transports move the tape continuously at a uniform speed. The stepping motors in the Redifon mechanism, however, move the tape only in discrete, intermittent steps. Speed reducing gears are used between the motors and the driving sprockets, and the system operates so that the tape starts quickly, advances at a nearly uniform speed during most of the step, and then stops quickly, as shown in Figure 2. Digital pulses are recorded or read only while the tape is being moved.

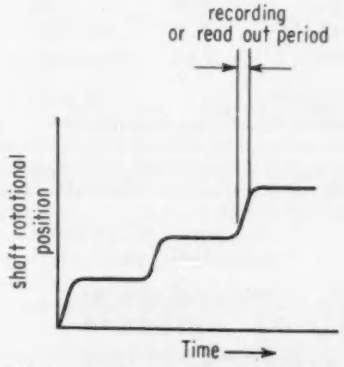


FIG. 2. Recording and reading is done only during time tape is being stepped.

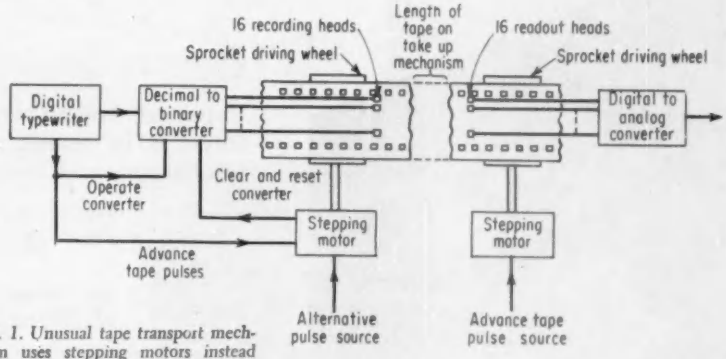


FIG. 1. Unusual tape transport mechanism uses stepping motors instead of continuous drive.

Figure 1 shows the digital data being supplied by a typewriter, but the input can come from almost any source (the RADIC system equipment includes an analog to digital converter so that analog inputs can be recorded as well). An operate pulse from the typewriter causes the stepping motor to advance the tape at the same time the binary data is read out of the decimal to binary converter to the recording heads. At the conclusion of the tape motion, a pulse is fed back to clear and reset the decimal to binary converter. Each channel corresponds to a binary bit-position (that is, 2^0, 2^1, 2^2, . . ., 2^{15}) so that a recording accuracy of 1 part in 10,000 can be obtained.

The provision of two separate stepping motors for recording and reading permits a variable time delay between recording and reading. The actual delay time depends on the length of tape between the two heads (which is stored in a loop held taut by a spring loaded pulley) and the average speed of the tape between the heads. This time delay can be constant or can be varied dynamically by making the pulse repetition frequency to one of the stepping motors different from that to the other motor.

The maximum delay is limited (assuming continuous data recording) only by the physical capacity of the takeup mechanism for tape between the two sprocket wheels. The minimum delay (about 0.5 sec) is limited by the minimum separation between the recording and reading heads.

Time multiplexing of several input channels is also simple by sampling the inputs sequentially with a commutating switch. The samples for each channel are thus recorded sequentially along the tape and repeated once for each revolution of the commutating switch.

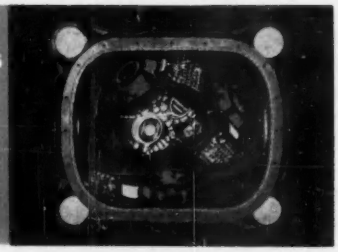
Tape speed control signals can be generated by an internal variable-frequency pulse generator or can come from an external source. The use of external pulses permits mathematical integration with respect to variables independent of time.

Inland

Now in Production for Second Generation Servos

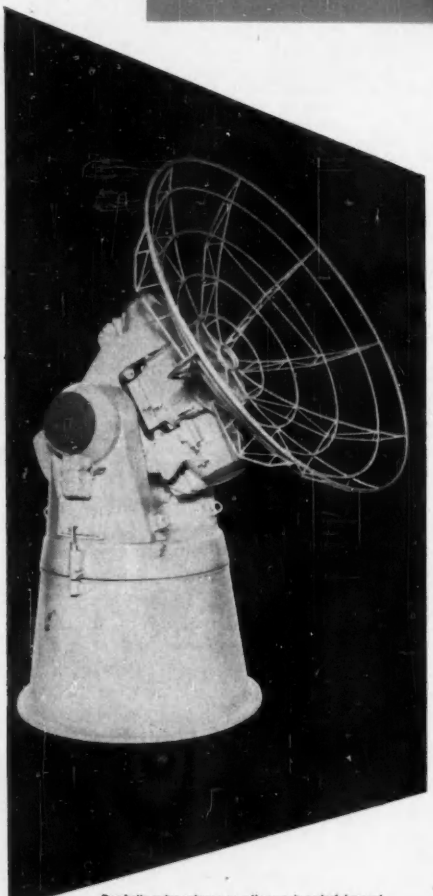
d-c torque motors

peak torques from 0.1 to 3000 pound-feet



Compact pancake d-c torquers in a wide range of sizes are now available for direct drive servo positioning in airborne, shipboard and ground service stabilization and tracking systems.

Miniature, four-gimbaled, Minneapolis-Honeywell inertial navigation platform currently applied to both terrestrial and space guidance systems. All four gimbals are equipped with Inland torquers having a peak output at stall of 60 ounce-inches.



Parabolic radar antenna on a three-axis pedestal mount manufactured by Reeves Instrument Corporation for the Philco Corporation. Direct drive motors for all three axes were provided by Inland. These range in output from 500 to 3000 lb-ft.

Exclusive Commutator and Brush Rigging Design

Patented Inland features make possible powerful d-c torquers in compact pancake shape. More torque, with smaller size and lower power input.

REPRESENTATIVE RANGE OF INLAND D-C TORQUE MOTORS

TYPE	PEAK TORQUE AT STALL	POWER INPUT FOR PEAK TORQUE WATTS @ 25°C	DIMENSIONS, INCHES O.D.	THICKNESS
T-1321	20 oz.-in.	57	1.94	.50
T-2136	35 oz.-in.	42	2.81	.63
T-2108	60 oz.-in.	32	2.81	1.00
T-2907	.85 lb.-ft.	79	3.73	1.09
T-4006	1.8 lb.-ft.	100	5.13	1.25
T-5106	2.7 lb.-ft.	86	6.25	1.31
T-5703	7.0 lb.-ft.	246	7.20	1.63
T-720	11.0 lb.-ft.	327	9.00	1.63
T-8001	25 lb.-ft.	925	10.50	2.63
T-10001	35 lb.-ft.	620	13.69	4.30
T-10004	100 lb.-ft.	1020	12.75	5.75
T-18002	300 lb.-ft.	1300	26.63	5.82
T-18004	900 lb.-ft.	4330	26.50	10.56
T-36001	3000 lb.-ft.	7400	45.0	10.25

For complete data on these or other Inland d-c pancake torquers, address Dept. CE, Inland Motor Corporation of Virginia, Northampton, Massachusetts.

INLAND AMPLIFIERS—Inland makes a complete line of amplifiers for systems duty with Inland torquers, whether in airborne, shipboard, or ground service. Specification sheets available on request.

Factory: Radford, Virginia

INLAND MOTOR CORPORATION OF VIRGINIA

A SUBSIDIARY OF KOLLMORGEN CORPORATION

NORTHAMPTON, MASS.

NEW PRODUCTS

NEW IDEA IN A CONTROL DEVICE combines d'Arsonval meter with precision pots.

Based on a brand new idea in meter design, the instrument shown here represents the first offering in CIC's new Metrol line. Basic design of the device involves the coupling of an infinite resolution potentiometer to a d'Arsonval meter movement and the use of these elements with a high gain amplifier to form a small, closed-loop servo.

The resulting instrument has a number of unique and valuable characteristics. Accuracy, for example, no longer depends on the uniformity of a magnetic field or hairspring. Instead, it becomes strictly a function of the feedback pot's linearity. Use of precision carbon film pots produces meters that are accurate to within 0.1 percent of full scale. Another feature is its response; manufacturer claims the meter will follow an input signal whose frequency is greater than 20 cps over an excursion greater than 75 percent of full scale. Since its pointer is locked in position by a functioning servosystem, the instrument can be subjected to a 10-g shock in any axis without visible pointer motion. For the same reason it can be mounted in any position without loss of accuracy or response.

Meter-relay application

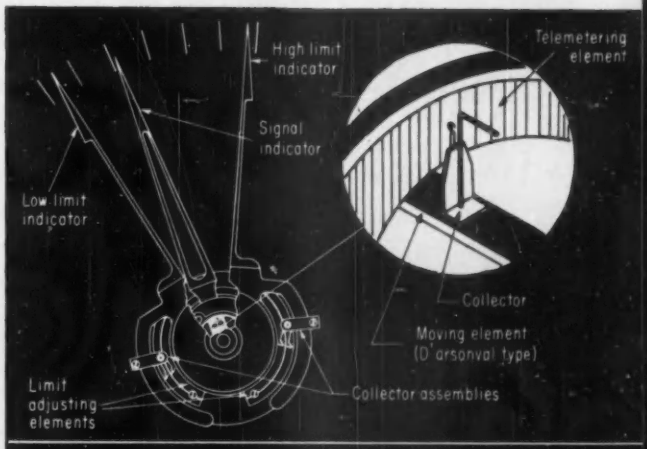
The accompanying photo, drawing, and circuit diagram illustrate a meter-relay configuration, the first commercial version of the instrument. The drawing just beneath the photo shows how the main pointer as well as the two limit indicators are coupled through collectors to the precision film pots. The electrical arrangement of these elements is shown in the circuit diagram. The output of the feedback pot is fed to two differential amplifiers where it is compared with the set voltages of the high and low limit pots. When in either of these amplifiers a zero-crossover is detected (i.e., when the signal pointer coincides with either of the limit indicators), the appropriate load relay is snapped in through a Schmitt trigger. Since limit sensing is strictly electronic, the pointer is free to move beyond the set limits without loss of accuracy and without putting any load on the meter movement. In this application the instrument has a repeatability of within 0.2 percent.

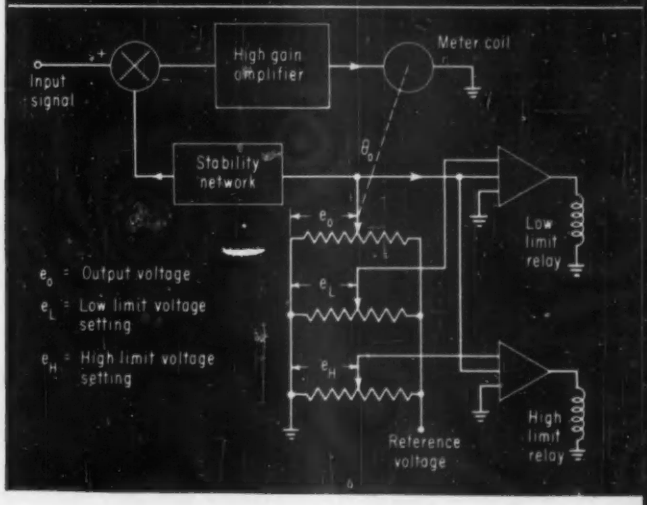
Other applications

Another feature of this instrument is its ability to use functionalized scales. Null indicators and ohmmeters are possible applications. With a nonlinear pot as its feedback element, for example, the device would become a linear scale ohmmeter. Several other forms of the basic device are planned for release in the near future. Additional potentiometer elements coupled to the feedback pot permit the meter to act as a dc synchro transmitter and receiver (with or without the scale and pointers). Combined with suitable thermocouples, the meter serves as a temperature controller. The basic unit, with contacts but without scale and pointers, becomes an excellent go/no-go comparator.—Computer Instruments Corp., Hempstead, N. Y.

Circle No. 309 on reply card

Meter relay (right) with its movement and circuitry (below)





NEW PRODUCTS

SYSTEMS

ADDITION TO LINE

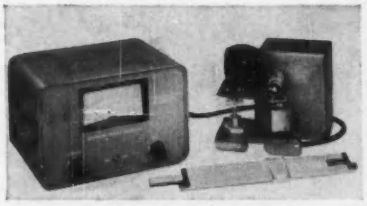
The new 1410 data processing system augments this manufacturer's previously announced 1401, providing greater speed and memory capacity—2½ times as much, in fact. Character transfer time of the new system is 4.5 microsec, and central processor can have up to 40,000 magnetic core memory positions. Another special feature is second channel on which processing can be carried out independently from operations on first. Typical RAMAC 1410 tape system would sell for $722,300; monthly rental: $18,105.—International Business Machines Corp., Data Processing Div., White Plains, N. Y.

Circle 310 on Reader Service Card

DESK PROCESSOR

Developed especially for business data processing, this desk sized E103 digital computer is said to be the lowest price general purpose computer on the market at $29,760; monthly lease is $875. Programs have been developed for the machine so that it can handle sales analysis, payroll, tax billing, etc. Features include magnetic drum memory of 220 words (12 digits plus sign each) and external pinboard programming.—Burroughs, Corp., Detroit, Mich.

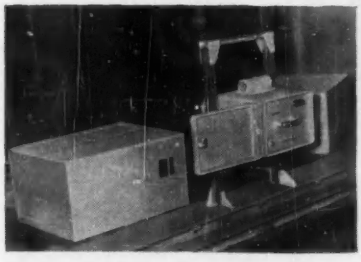
Circle 311 on Reader Service Card



PROCESS REGULATORS

Shown above is the pressure regulating unit from a new line of electronic process regulators. Three models cover a range from 30 in. Hg to 5,000 psig. System consists of servovalve, electronic controller/amplifier, and pressure transmitter. Error can be as low as 0.2-0.4 percent of transmitter range. Price: $650-1,700. Other regulators in the line are for flow, valve position, and temperature.—Physics for Industry, Inc., Rochester, N. Y.

Circle No. 312 on reply card



COUNTS CONTAINERS

The fully automatic electronic selector and counter shown installed above optically selects and counts up to 31 different types of items for discharge and routing. Codes printed on containers are recognized photoelectrically to actuate the counting unit and conveyor switch.—Atronic Products, Inc., Bala-Cynwyd, Pa.

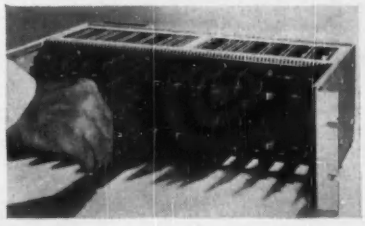
Circle No. 313 on reply card

TELEPHONED DATA

Designed to operate with the Bell System's Data-Phone 200, this Dial-o-Verter System makes possible the transmission and receipt of volumes of data to and from remote locations. The system is based on the manufacturer's D599SR coupler, which forms the interconnection between the Data-Phone and any common data media: paper or magnetic tape or punched cards. When transmitting, it uses a high speed tape or card reader; when receiving, a punch or tape recorder. Data are transmitted over telephone line at 1,500 words per min.—Digitronics Corp., Albertson, N. Y.

Circle No. 314 on reply card

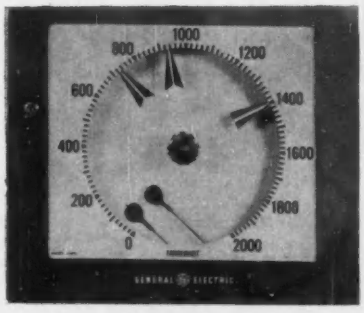
DATA HANDLING & DISPLAY



COMPARES 100,000 PER SEC

Solid state circuitry is used in a new programmable comparator capable of comparing measurement numbers at rates as high as 100,000 per sec. Its maker says it is the only programmable comparator made in the U.S. and is faster than any other available. Accepting input information, say digital data from an analog to digital converter, the device compares it with present limits and answers in terms of "Go", "No Go High", or "No Go Lo". Price: approximately $2,000.—Leach Corp., Compton, Calif.

Circle No. 315 on reply card



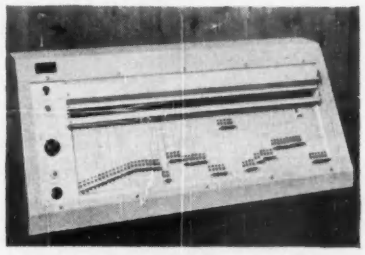
TWO-PEN RECORDER

This new two-pen round chart recorder/controller is accurate to within ±¼ percent. An adaptation of an earlier single pen model, the new design can be used almost anywhere in industry where two variables must be recorded on a single chart. Measurement circuits may be potentiometric,

NEW PRODUCTS

bridge-type, or both in combination. Zener diodes eliminate cells and offer voltage reference accurate to ±0.05 percent. Minimum scale span is 1 mv dc. Response times are 4, 10, and 24 sec full scale. Concentric scale length is 27.5 in. Pen speeds are 1, 8, 12, or 24 hr or 7 days. Price: approximately $1,500.—General Electric Co., Schenectady, N. Y.

Circle No. 316 on reply card



SEMIAUTOMATIC SENDER

Developed for the Air Force's weather information system but applicable to other rapid data transmission needs, the Telecode transmitter shown above sends 72-character messages semiautomatically. The messages are chosen by setting 72 movable character switches set side-by-side; each switch can be set at any of 52 alphabetic, numeric, or special Type D teletype code symbols. The message is visible in a panel on the transmitter's front face. A push of a button or an interrogate signal from a receiving unit transmits the message that has been set up. A particular advantage is that the entire message does not have to be reset to change just a few characters. Price: about $7,000. Wang Laboratories, Inc., Natick, Mass.

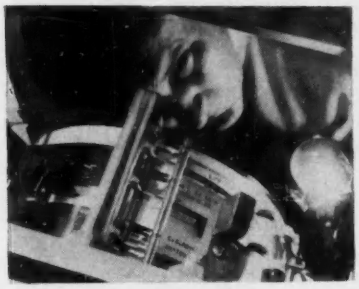
Circle No. 317 on reply card

ANSWERS QUERIES

This new electronic inquiry station displays in alphanumeric characters answers to questions put to a data processing system. The station converts the reply into a video signal from the digital signals provided by a computer, punched cards, or paper or magnetic tape. Information appears on a 14-in TV tube in an array of 10 lines, 19 characters per line. Display remains until erased by the operator. A total of 64 different characters can be displayed at rates up to 190 characters per inquiry. Unit measures 22 in.

deep, 26 in. wide, and 51 in. high with a shelf overhang of 18 in. Price: depending on special features, about $15,000.–A. B. Dick Co., Chicago, Ill.

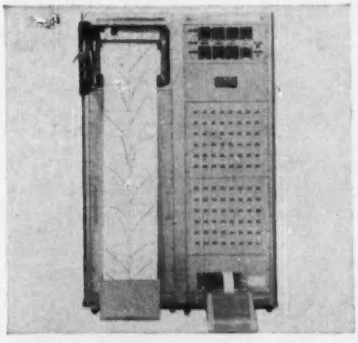
Circle No. 318 on reply card



OPTICAL READER

Both typed and printed business information can now be read directly into a computer memory using the new 1418 optical reader. The unit reads data in widely used type styles at the rate of 480 characters per sec. Output is translated into machine language to go directly to the manufacturer's 1401 computer. Forms acceptable can be from 5⅞ to 8¾ in. long by 2¾ to 3¼ in. wide. Price for the reader is $120,300-133,800; monthly rental: $2,600-3,750.–International Business Machines Corp., Data Processing Div., White Plains, N. Y.

Circle No. 319 on reply card



PLOTS STRAIN GAGE DATA

Now available off the shelf rather than on a custom built basis only, a new line of strain gage plotters provides multichannel recording and plotting for either 48 or 96 channels. No manual plotting or reading is necessary; the Model 114 automatically records data in visual form for on-the-spot evaluation. Individual graphs are used for each channel, and three zero positions are available for each. Special models are available for thermocouple or for millivolt input, and custom features allow speeds up to 20 channels per sec. – Price: 48-channel, $9,000; 96-channel, $13,000.–Gilmore Industries, Inc., Cleveland, Ohio.

Circle No. 320 on reply card

PLUS . . .

(321) The CM-114 Extends the range of the **video band recorder/reproducer** series manufactured by **Mincom Div. of Minnesota Mining and Manufacturing Co.**, Los Angeles, Calif., to 14 tracks and has frequency response of 400 cps to 1 Mcps at 120 ips. . . . (322) The **Electro Mechanical Instrument Div. of Consolidated Electrodynamics Corp.**, a Sub. of Bell & Howell Co., Pasadena, Calif., has developed a portable, **$2,290 oscillograph** recommended for use in utilities and research labs. . . . (323) A **single point recorder** with full scale pen speed of ½ sec has been placed on the market by **Daystrom, Inc., Weston Instruments Div.**, Newark, N. J.

Circle No. 321, 322, or 323 on reply card

RESEARCH, TEST, & DEVELOPMENT

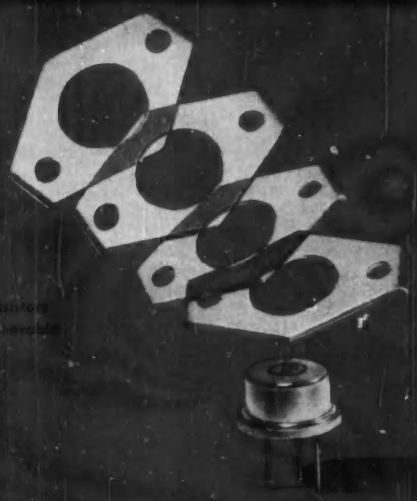
HIGH SPEED GENERATOR

The Model 1200 millimicrosecond programmed current pulse generator delivers a high amplitude, ultrashort current or voltage pulse for research and development of high speed magnetic materials, solid state devices, and computer circuits. It provides pulse repetition frequencies from 500 pps to 5 Mcps. Pulse widths range from 20 millimicrosec to 15 microsec, and maximum current pulse amplitudes are 2 amp. The equipment is housed in a standard rack cabinet 78 in. high, 23½ in. wide, and 21 in deep. Power supplies are mounted in a separate rack cabinet.–Rese Engineering, Inc., Philadelphia, Pa.

Circle No. 324 on reply card

SIGNAL SIMULATOR

Precise PAM, PDM, or PAM/NRZ pulse trains are the output of this electronic signal simulator for calibration and checkout of telemetry equipment. Features include continuously variable pulse rate from 20 to 7,000 pulses per sec, programmable signal levels, zero



New RCA intermediate-Power Transistors feature JEDEC TO-8 case with reversible heat-sink mounting flange

6 NEW RCA INTERMEDIATE POWER TRANSISTORS

Now—in production quantities—six new RCA PNP germanium alloy junction transistors designed primarily for intermediate-power switching and audio-frequency industrial and military applications. Featuring 100°C maximum junction temperature and a unique case design, these new types can be used with or without the heat-sink mounting flange. With mounting flange in place, these types can dissipate 7.5 watts at 25°C case temperature; without flange, one watt at 25°C.

These new RCA intermediate-power transistors provide a choice of voltage ratings and beta ranges for design flexibility. They feature low saturation resistance and low leakage current.

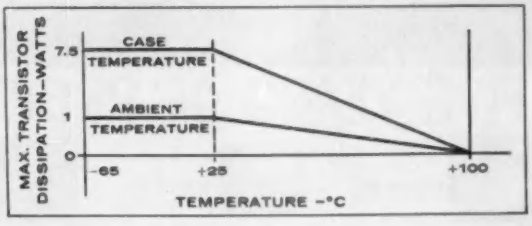
They are particularly useful in power switching circuits such as dc-to-dc converters, inverters, choppers, solenoid drivers, and relay controls; oscillator, regulator, and pulse-amplifier circuits, and as class A and class B push-pull amplifiers for servo and other audio-frequency applications.

RCA intermediate-power germanium transistors were developed in cooperation with the U. S. Army Signal Corps on an Industrial Preparedness Measure for military devices.

Call your nearest RCA field office today for full particulars. For further technical information write RCA Commercial Engineering Sec L-56-NN, Somerville, N. J.

ELECTRICAL CHARACTERISTICS

Type	Min. V_{CES} (I_C = −50 ma)	Min. V_{CEO} (I_C = −50 ma)	Min. V_{CBO} (I_{CBO} = −250 μa)	Min. V_{EB} (I_E = −100 μa)	h_{FE} (I_C = −400 ma)
2N 1183	−35v	−20v	−45v	−20v	20-60
2N 1183A	−50v	−30v	−60v	−20v	20-60
2N 1183B	−60v	−40v	−80v	−20v	20-60
2N 1184	−35v	−20v	−45v	−20v	40-120
2N 1184A	−50v	−30v	−60v	−20v	40-120
2N 1184B	−60v	−40v	−80v	−20v	40-120



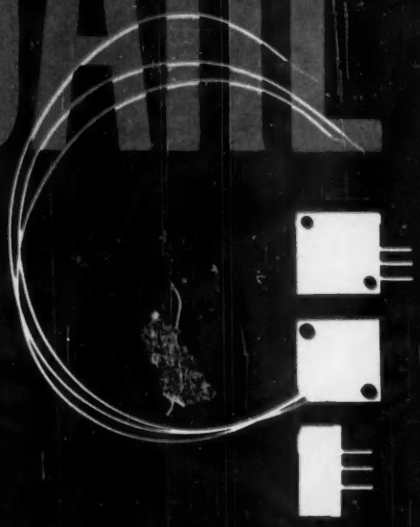
ANOTHER WAY RCA SERVES YOU THROUGH ELECTRONICS

RCA SEMICONDUCTOR & MATERIALS DIVISION FIELD OFFICES...EAST: 744 Broad Street, Newark, N. J., HUmboldt 5-3900 • NORTHEAST: 64 "A" Street, Needham Heights 94, Mass., HIllcrest 4-7200 • EAST CENTRAL: 714 New Center Building, Detroit 2, Mich., TRinity 5-5600 CENTRAL: Suite 1154, Merchandise Mart Plaza, Chicago, Ill., WHitehall 4-2900 • P.O. Box 8406, St. Louis Park Branch, Minneapolis, Minn., FEderal 9-1249 • WEST: 6355 E. Washington Boulevard, Los Angeles, Calif., RAymond 3-8361 • 1838 El Camino Real, Burlingame, Calif., OXford 7-1620 • SOUTHWEST: 7905 Empire Freeway, Dallas 7, Texas, FLeetwood 7-8167 • GOVERNMENT: 224 N. Wilkinson Street, Dayton, Ohio, BAldwin 6-2366 • 1725 "K" Street, N.W., Washington, D. C., FEderal 7-8500.

Available through your RCA Distributor

The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

SQUARETRIM



FIVE YEARS OF PROVEN TRIMMER PERFORMANCE

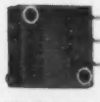
(ACTUAL SIZE)
SERIES 300

SERIES 301

SERIES 311

SERIES 313

SERIES 315
SERIES 316



THE ONLY SQUARE TRIMMING POTS WITH OVER 2,000,000 UNITS DELIVERED

Daystrom SQUARETRIM potentiometers may look like the many square configuration copies which have been flooding the industry in recent weeks, but they are different. This difference is in their outstanding performance, reliability and broad-line availability. Daystrom has had five years to develop, produce and field-prove the features of the SQUARETRIM potentiometers, so whatever features are important to your application, you can be sure that there is a Daystrom SQUARETRIM to meet your most exacting requirements.

The proof that Daystrom delivers what it promises can be found in over 2,000,000 Daystrom SQUARETRIM's which have been placed into customer operation since 1955. It costs no more to be sure, so when you are ready to order trimming potentiometers, contact your nearest Daystrom Representative or Distributor for immediate delivery. Or you may write the factory direct for Data File CE 1350-1.

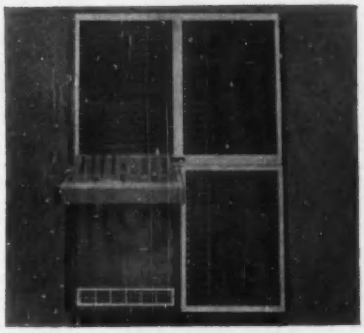
DAYSTROM, INCORPORATED
POTENTIOMETER DIVISION
Archbald, Pennsylvania • CAnal 6-3300 (New York, N.Y.)

CIRCLE 146 ON READER SERVICE CARD

NEW PRODUCTS

and full scale pulses anywhere within the frames, and provision for application of noise to the pedestal and information levels of the wave train. Linearity is within 0.15 percent of full scale, and stability in output (PAM) and pulse width (PDM) is within 0.15 percent of full scale for 12 hr after 45 min warmup.–Telemetrics, Inc., Gardena, Calif.

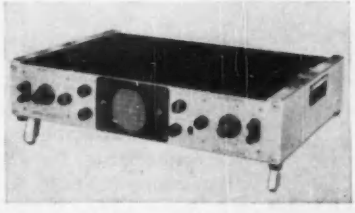
Circle No. 325 on reply card



NIFTY CHECKER

An electronic tester which reduces time spent checking wiring of complex electronic equipment has been tradenamed NIFTE for Neon Indicator Flashing Test Equipment. Originally developed to check the manufacturer's own production of digital computers, the tester has proven useful in improving quality and reducing costs. It can be used economically for testing as few as 50 or as many as 18,000 circuits.–Autonetics, Div. of North American Aviation, Inc., Downey, Calif.

Circle No. 326 on reply card



CALIBRATES INSTRUMENTS

This compact Lissajous oscilloscope can be used as a bench instrument or can be mounted in a standard 19-in. relay rack in which it takes up only 3½ in. of panel space. The Liss-A-Scope, as it is trademarked, is designed to simplify phase shift measurement and monitoring. It is readily applicable to most lab or factory testing or calibration of phase measuring instruments or other components having phase shift characteristics. Sensitivity is from 0.005 to 300 volts per cm in 10 calibrated ranges with frequency range from 5 cps to 1 Mcps.–North Atlantic Industries, Inc., Plainview, N. Y.

Circle No. 327 on reply card

PLUS. . .

(328) **Rotek Instrument Corp.,** Cambridge, Mass., has announced at $4,975 an ac **reference standard** for lab work with accuracy not previously available. . . . (329) An accurate measure of density for a wide range of substances is available using the **pycnometer** introduced by **Beckman Instruments, Inc.,** Fullerton, Calif., at $545. . . . (330) **A polargraphic** analyzer priced at $795 with highest flexibility is being sold by **Nesco Instruments, Inc.,** Costa Mesa, Calif.

Circle Nos. 328, 329, or 330 on reply card

PRIMARY ELEMENTS & TRANSDUCERS

DETECTS HYDRAULIC LEAKS

Any leakage in a hydraulic system under test with the new Model 410 results in a displacement of a piston which is separated from the fluid by a bellows. This displacement is measured by a position transducer and displayed on a volume indicator dial. Maximum displacement is 2 cu cm, and leaks as small as 0.0025 cu cm can be measured accurately. Price: $2,650.—Convair Instruments, Convair Div., General Dynamics Corp., San Diego, Calif.
4X-14

Circle No. 331 on reply card

DIME-SIZE TRANSDUCER

A new flush diaphragm absolute pressure transducer has been drastically reduced in size and weight so that it is no larger than a dime. Featuring

NEW PRODUCTS

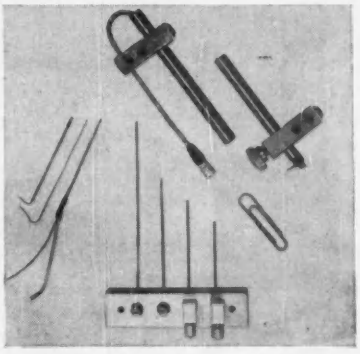
also a flush diaphragm with high frequency response, the device is just 0.590 in. in diam and 0.050 in. thick. Pressure ranges are 0-10 and 0-100 psi.—Statham Instruments, Inc., Los Angeles, Calif.

Circle No. 332 on reply card

FIRE DETECTOR

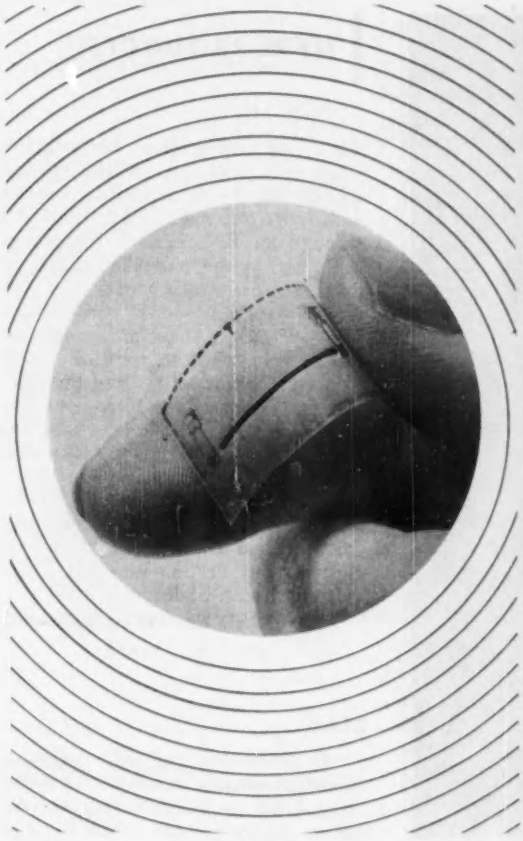
Smaller than a golf ball, the U-V Detector is an electronic tube capable of detecting fire by sensing its ultraviolet radiation. It was developed to be used as a fire detector to provide nearly instantaneous alarm or to warn of flameout in combustion chambers. The device is insensitive to direct sunlight, normal illumination enclosed in glass, and cosmic and nuclear radiation. The detector is 1⅛ in. long including mounting pins to fit an ordinary radio tube socket. With control it is priced at $80.—Thomas A. Edison Industries, Instrument Div., McGraw-Edison Co, W. Orange, N. J.

Circle No. 333 on reply card



VELOCITY PINS

A new system for measuring velocity in liquids or gases uses coaxial probes in clusters to read out a velocity pro-



MICRO-STRESS INSTRUMENTATION

Orders of Magnitude More Sensitive
SEMICONDUCTOR STRAIN GAGE
MICRO-SENSOR MS 105-350

For Application to: Structural Members • Transducer Sensors

FEATURING

- Sensitivity—gage factor 130
- Easily bonded to all types of surfaces for military, industrial, and space applications
- Integral terminal construction
- Superior signal-to-noise ratio
- Resistance—350
- Size: Element—⅝" x .020" Complete Gage—1" x ½"
- Radius of Curvature—½"
- Maximum Operating Strain—over 3000 microstrain

IMMEDIATELY AVAILABLE—
ADDITIONAL INFORMATION ON REQUEST

MICRO SYSTEMS INCORPORATED

CIRCLE 195 ON READER SERVICE CARD

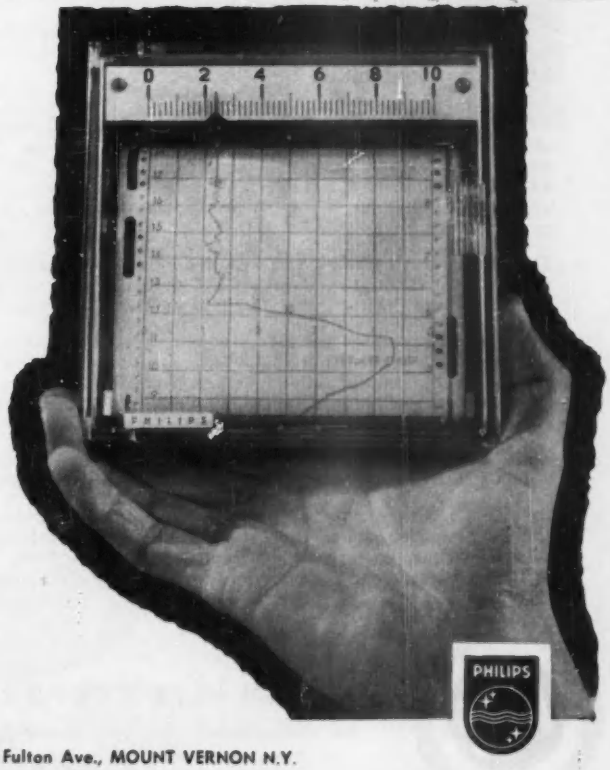
NBO

PHILIPS
miniature recorder

type PR 2400 A
for mV and temperature measurements

Panel space 144 x 144 mm (5¾ x 5¾ ins.)

- Reliable null-balancing potentiometer system
- Easily interchangeable ranges.
- Transistorized plug-in amplifier with printed wiring.
- Unique chart-winding system.
- High indicating-speed and critical damping
- Scale calibration for mV and all conventional thermocouples
- Completely mains operated.



U.S.A.: Philips Electronics Inc., Instrument Division, 750, South Fulton Ave., MOUNT VERNON N.Y.
Canada: Philips Electronics Ltd., 116 Vanderhoof Ave., TORONTO - Ontario
Overseas inquiries: N.V. Philips' Gloeilampenfabrieken - Eindhoven - Holland

NEW PRODUCTS

file. The probes act as fast switches when their end caps–in the moving sample stream–are pushed in contact with inner electrodes. Signals are fed through an RC network that codes the pulses by shape and/or polarity to enter a spiral sweep generator which serves as input to an oscilloscope. Types of probes being made available include: Type A to measure shock fronts in liquids or gasses (top right in photo above); Type B, an open pin to measure velocities of conducting materials (top center); Type C, a self-shorting pin for velocities of materials like rocket fuels (left); and Type D to measure velocity of ionized gases. Lowest price individual pin is $1.40; clusters start at $8.–Research Products Associates, Stamford, Conn.

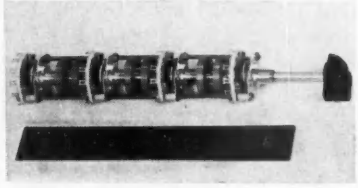
Circle No. 334 on reply card

PLUS. . .

(335) Extremely rugged, precision miniature **pressure transducer** for measuring 0-400 or 0-10,000 psig or psia gas or liquids is now available from **Fairchild Controls Corp., Sub. of Fairchild Camera & Instrument Corp.,** Hicksville, N. Y., at $985. . . . (336) The **Industrial Balancer Div. of Stewart-Warner Corp.,** Chicago, Ill. has recently introduced **a device for protecting equipment** from damage due to excessive vibration (price: $850).

Circle No. 335 or 336 on reply card

CONTROLLERS, SWITCHES & RELAYS

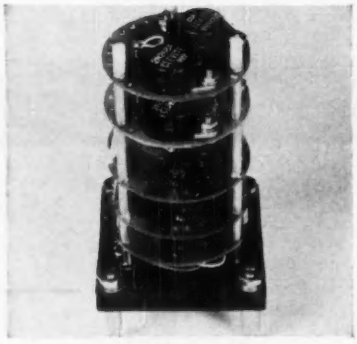


COMBINATION LOCK MEMORY

An electrical memory switch that uses the principles of an ordinary combination lock is capable of storing multiple digit numbers. In operation the switch is first cleared and then digits are set in by turning the shaft alternatively right and left. The

switch consists of switch indexes and wafers arranged coaxially with tumbler-type couplings in between. The number of digits to be stored determines the number of indexes needed. That shown above has four indexes for four digits and has 12 positions on each index to allow digits 0 to 9 and plus or minus indication. Availability has not yet been announced.—Instrumentation Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.

Circle No. 337 on reply card



2,500 BIT PER SEC RELAY

Operating as a single pole, single throw unit with input coil and output circuit isolation, this semiconductor relay operates at up to 2,500 bits per sec. Its output transistors are operated in series or parallel to key circuit loads of up to 300 vdc.

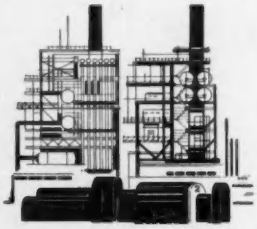
Characteristics:

Input current: 10-80 ma max, 20-60 ma nominal
Input resistance: 135 ohms
Max open circuit voltage per dual "contact" unit: 150 volts
Maximum safe "contact" current: less than 1 volt
Quantity price: less than $100
—Rixon Electronics, Inc., Silver Spring, Md.

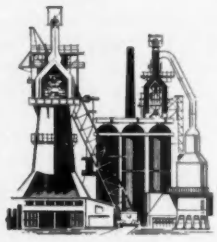
Circle No. 338 on reply card

CONTROLS ULTRASONICALLY

This unique ultrasonic switch allows a safe means of controlling levels of all liquids including corrosive or explosive

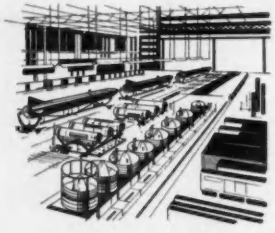


ELECTRIC POWER

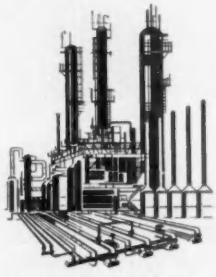


STEEL

RW-300



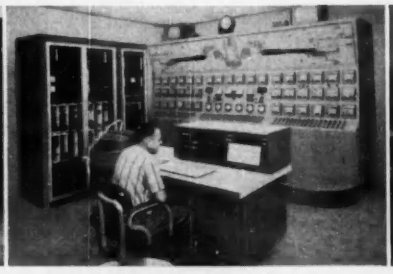
AIRCRAFT AND MISSILES



OIL REFINING AND CHEMICALS

OVER 200,000 HOURS...BETTER THAN 99% RELIABILITY

Federal Aviation Agency, Atlantic City, New Jersey—air traffic control simulation



Riverside Cement Company, Oro Grande, California—cement manufacturing

Douglas Aircraft Company, Santa Monica, California—missile component testing

TRW Computers Company

a division of ***Thompson Ramo Wooldridge Inc.***

202 NORTH CANON DRIVE • BEVERLY HILLS, CALIFORNIA

NEW PRODUCTS

fluids. The explosion-proof stainless steel probe instantly actuates the device when any liquid touches its sensitive surafce. Repeatability is within a few thousandths of an inch, and operation is possible at pressures over 2,000 psi. There are no moving parts to foul. The controller is available with indicating lights or aural annunciators.—Powertron Ultrasonics Corp., Garden City, N. Y.

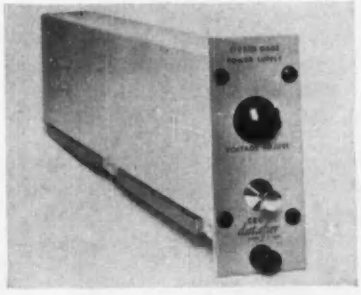
Circle No. 339 on reply card

20-POLE REED RELAY

A complete line of encapsulated dry reed relays in 1, 2, 4, 12, and 20-pole types now announced features any combination of NO or NC contacts. Break-make action can be furnished to insure nonoverlapping of contact closures. The relays are available with several coils controlling a single reed so that they may be used as logic units. All units are $1\frac{7}{8}$ in. long and vary from a 0.585 in. diam for the one-pole unit to 1 x $1\frac{1}{2}$ in. for the 20-pole type—Struthers-Dunn, Inc., Pitman, N. J.

Circle No. 340 on reply card

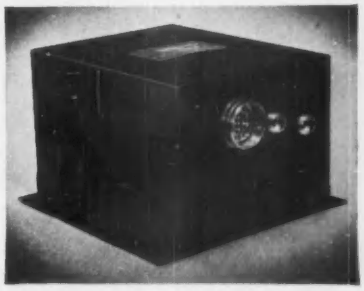
POWER SUPPLIES



LOW DRIFT SUPPLY

The solid state circuitry of the Type 3-139 strain gage power supply is fully isolated from the ac line supply by a triple box shielded power transformer to assure common mode rejection in an instrumentation system. Featuring low output drift (less than 0.1 percent from 0 to 50 deg C for all load and output conditions), the unit has an output voltage continuously variable 2-15 volts and an output current of 0-200 ma. Operating voltage is 95-135 vac, 50-400 cps. Eight plug-in units will fit in $5\frac{1}{4}$ in. of RETMA rack. Price: $195.—Electro Mechanical Instrument Div., Consolidated Electrodynamics Corp., Sub. of Bell & Howell Co., Pasadena, Calif.

Circle No. 341 on reply card



EXTREMELY STABLE

Designed to supply the sweep potential to a high persistance display tube used in a bomb-nav system, this highly stable power supply delivers 2,000 vdc under a variety of severe environmental conditions. Output is regulated to with in ±1 percent under the following conditions: load current changes from 0 to 2.4 ma, input voltage variation from 102 to 124 over a range of 380-420 cps, and ambient temperature changes from −54 to +71 deg C. Output voltage ripple is less than 400 mv. The $7\frac{1}{2}$-lb supply measures $4\frac{1}{2}$ x $5\frac{3}{4}$ x $6\frac{3}{4}$ in. Price: $1,500-2,000.—Industrial Products Div., International Telephone and Telegraph Corp., San Fernando, Calif.

Circle No. 342 on reply card

LOW FI, LOW PRICE

A new low cost ($95) dc power supply is designed for uses in research labs which do not require close regulation or extremely low ripple. All solid state, the supply provides an output continuously variable in three ranges: 0-6, 0-30, and 0-60 vdc at 1 amp max. Maximum output ripple is 50, 200, and 300 mv rms on the respective ranges. Input required is 115 volts, 60 cps, single phase.—Consolidated Avionics Corp., Westbury, N. Y.

Circle No. 343 on reply card

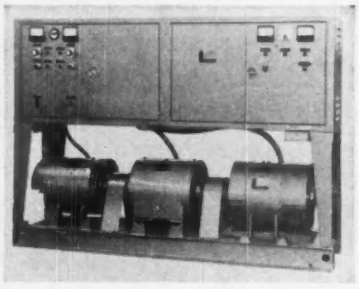
MULTIPLE POWER

This low cost multiple power supply for custom digital systems is a compact, rugged unit that will provide all the voltages required for the operation of most medium size digital systems. It is designed to mount in standard 19-in. racks. Price: $598.—

NEW PRODUCTS

Harvey-Wells Electronics, Inc., Natick, Mass.

Circle No. 344 on reply card



UNINTERRUPTED POWER

Three types of uninterrupted power systems are for applications which cannot endure even momentary loss of power to the load circuit. The three are: 1) unidirectional system having vital load isolated from the normal power supply, 2) unidirectional system having load supplied jointly from the power system itself and the normal power supply, 3) and a bidirectional system having the load isolated from the normal power supply. All three units feature a storage battery (which supplies power to the vital load circuit following loss of normal supply), a dc device, and an ac generator. Price less standby batteries: about $5,000.—Kearfott Div., General Precision, Inc., Little Falls, N. J.

Circle No. 345 on reply card

ACTUATORS & FINAL CONTROL ELEMENTS

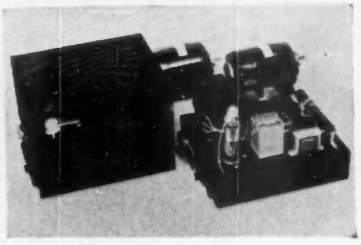


TABLE MOVERS

These Twin Drives are suitable for point to point or continuous table movement control and are easily pro-

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for the Design Engineer

The North RVF Switch is more than a component—it becomes a tool in the hands of the imaginative design engineer, giving him maximum flexibility in circuit approach coupled with reliable service, long life, positive action and a minimum of simple maintenance.

Any combination up to 30 inputs and/or outputs per bank level and up to 6 levels with single wiper or 15 points per level and 12 levels with double wiper for application in control circuits and systems involving selection, sequential operation, scanning or totalizing.

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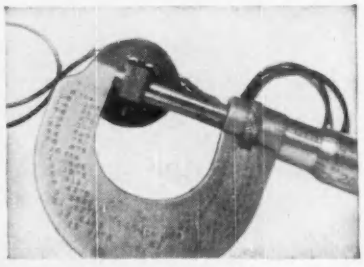
NEW PRODUCTS

grammed to follow an unlimited number of input signals to change speed or mode of operation. Commands can be received manually, electrically, or electronically; inputs via punched tape are easily accommodated. The drivers are available in ratings from 1/40 to 3 hp. Z-axis and rational axis companion drives are also included in the line. Price: $650-2,500 a pair.–ECI Manufacturing Div., Electronic Controls, Inc., Stamford, Conn.

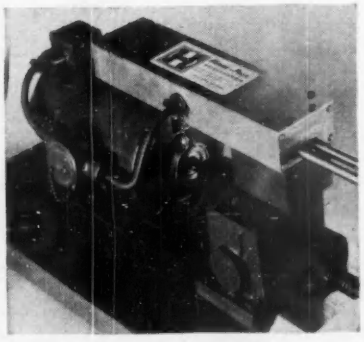
Circle No. 346 on reply card



MINIMOTOR

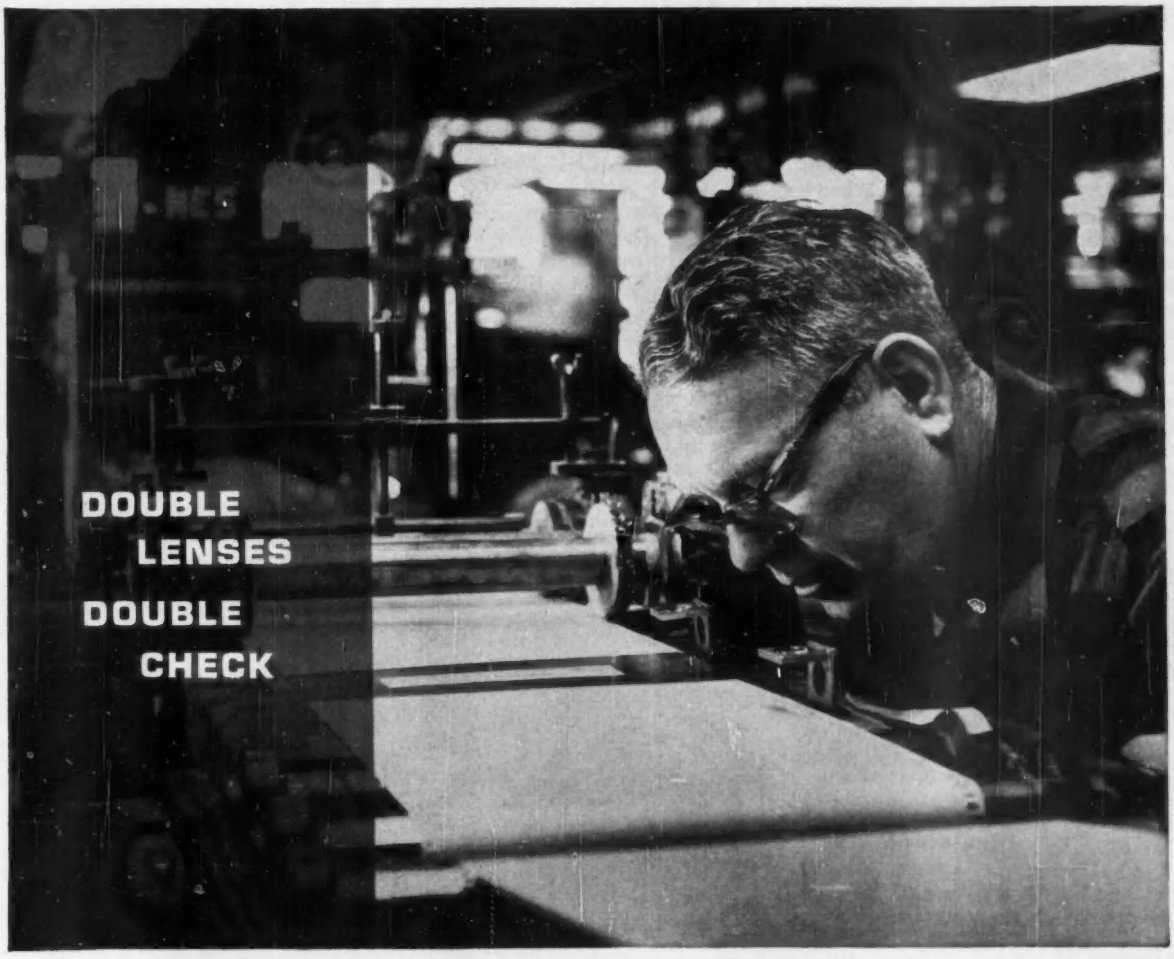
Certainly one of the smallest motors ever built, this ¼-in. wide motor is now available for prototype production. Height is 0.350 in. as is length. The large base on which the device is shown mounted above is for convenience in handling only; it is not needed for operation. On 1½ vdc the speed of the motor is 20,000 rpm and torque available is approximately 1 gm-cm. Weight is practically negligible: about ⅛ oz. Because of tiny size, armatures must be hand wound. Prototype price: $110.–Rosekilly Machinery, San Mateo, Calif.

Circle No. 347 on reply card



MULTIPLE POSITIONER

This electromechanical servo device can be used to position almost anything–machine tools, valves, float lev-



. . . for the precise calibration that means RECORDING CHART DEPENDABILITY

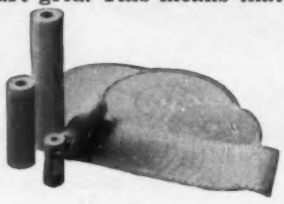
Charlie Robinson, our pressroom supervisor, is making a careful chart calibration check in the picture above. He does this often.

To make this test Charlie uses two engraver's glasses, a special templet . . . and the 50 years of chart printing experience that stands behind every GC Recording Chart.

What this test involves is making sure that the center line of the circular punches on a GC Strip Recording Chart is always the same distance — the *correct* distance — from the zero line of the chart grid. This means that a 25 psi recording at the end of a process, for example, will have the same value as a 25 psi recording at the start.

Take rigid inspection standards like these — and add repeated paper and ink tests, continuous humidity control in production and storage areas, and speed of printing and delivery. You'll see why more than 5,000 chart users rely regularly on GC dependability.

GC stocks more than 15,000 different chart types. We design and print charts for special purposes. Why not send now for the GC Stock List and for specific sample charts?



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D-C AMPLIFIER EVALUATION *number 1 in a series*

AMPLIFIER NOISE

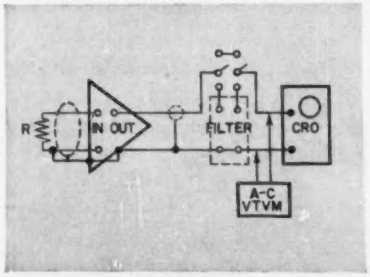
Accuracy is the basic objective in amplifier selection. When evaluating amplifiers for specific applications all errors must be considered. One such error, the noise level, determines the ultimate accuracy of the amplifier since the smallest observable signal cannot be less than the noise level. However, noise outside the frequency response range of the amplifier load can be filtered out or ignored with such read-out devices as galvanometer oscillographs.

Noise in an amplifier is any voltage component appearing at the output that has no counterpart in the input signal. Usually only the a-c component of the output is termed noise. The d-c component is called zero drift and its evaluation will be covered in another of this series.

Internally generated a-c components must be evaluated as to amplitude and frequency range. Noise may be divided into two general classes and measured as described below. (a) *Random voltages* of a broad band nature arising from thermal agitation in resistors and random tube or transistor noise . . . measurements on a peak-to-peak basis are often 10 times or more larger than the measured rms value over the same frequency band. (b) *Narrow band voltages* induced within the amplifier by line voltage or chopper excitation . . . these voltages are generally sinusoidal so that peak-to-peak values are only about 2.8 times larger than the measured rms values.

Testing amplifiers for noise

If the input signal is zero, any voltage components detected at the

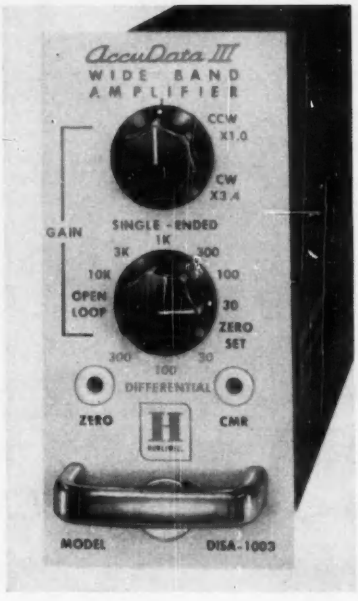


amplifier output can be identified as noise. A standard technique for measuring noise is shown.

The oscilloscope measures the peak-to-peak values, the VTVM in rms values. Equivalent input noise (eq. in) is the measured noise divided by the amplifier gain. For details write for Bulletin BE AN121.

Noise less than 0.04%

With a full scale input signal of 10 mv, Honeywell's AccuData III Amplifier has a wide band (0-100 kc) noise specification of 4 μv (eq. in) and a peak-to-peak noise over a 0-10 cps band of 4 μv (eq. in) . . . less than 0.04% of full scale!



The AccuData III, a wide band differential input d-c amplifier with all transistor design, is especially useful for driving analog-to-digital converters, f-m magnetic tape systems and high speed oscillographs where low level signals such as thermocouple, strain gage and similar transducer outputs are to be accurately measured. Write for Bulletin BS-DISA-3 to Minneapolis-Honeywell, Boston Division, Dept. 34, 40 Life Street, Boston 35, Mass.

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NEW PRODUCTS

els, etc.—to any of several preset positions. Up to 14 positioning stops can be installed per foot of positioner, and the positioner is available in lengths up to 8 ft. Positioning error is ± 0.005 in. depending upon load and type of applications. List price of four-switch package: about $135.—Hanna Engineering Works, Chicago, Ill.

Circle No. 348 on reply card

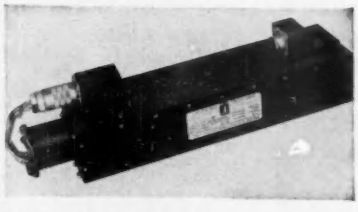
EXTREME TEMPERATURES

This split capacitor induction motor features continuous operation over an ambient range of −55 to +125 deg C. Manufactured by the company's Hertner Electric Co. subsidiary, the motor is designed to exhibit low starting torque.

Characteristics:
Horsepower: 1/400
Voltage: 115, 400 cps, 3-phase
Speed: 10,500 rpm
Torque: 0.24 oz-in. at full load; 0.20 oz-in. at starting
Weight: 3.5 oz
Quantity price: $35
—Kearfott Div., General Precision, Inc., Little Falls, N. J.

Circle No. 349 on reply card

COMPONENT PARTS



VARIABLE DELAY

Set up to be built to individual requirements, these delay lines offer delays continuously variable from 2

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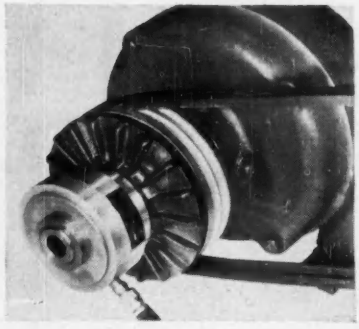
CIRCLE 159 ON READER SERVICE CARD 159

NEW PRODUCTS

to 10,000 microsec. Digit rate or bandwidth can be up to 500 kcps, reproducibility and linearity of setting is to within 0.1 percent, and jitter is less than 1 millimicrosec. Control is provided by low torque recirculating ball race drive suitable for manual or servo control.—Ferranti Electric, Inc., Electronic Div., Hempstead, N. Y.

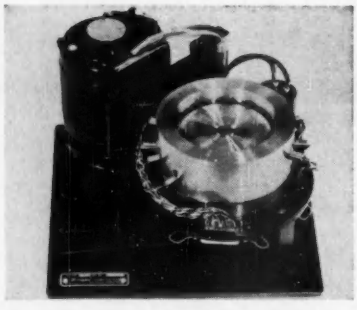
Circle No. 350 on reply card



STARTS WITHOUT SHOCK

Weighing only 15 lb, this new air operated clutch is suitable for applications up to 5 hp at 1,800 rpm. The clutch is able to give shockless starts without overheating, is self-adjusting, has antifriction bearings, requires no rotary joint, and is a combination motor sheave and clutch. Price: $116. Horton Manufacturing Co., Minneapolis, Minn.

Circle No. 351 on reply card



COMPACT STORAGE DRUM

Designed to meet the specifications for buffer storage to magnetic tape, this compact, low cost magnetic storage drum can be supplied with matching read-write circuitry. The high speed device, suitable for severe industrial environments, can also be used as medium access storage for data reduction or processing systems. Versatility

is provided by a pulley and belt drive which is replaceable to provide speeds to 25,000 rpm. Capacity is 100,000 binary bits. Small lot price: $1,500.—Farrington Manufacturing Co., Needham Heights, Mass.

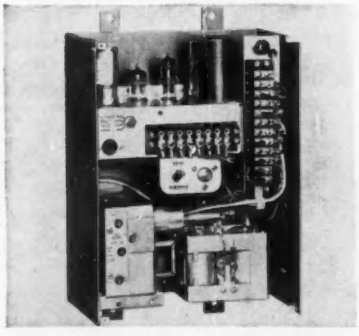
Circle No. 352 on reply card

NAND MODULES

These high speed digital plug-in modules feature NAND circuitry and are priced at less than $20 per flip-flop. Frequency range is dc to 1 Mcps. High packing density allows 19 or, where required, 28 of these printed circuit cards (each 4½ in. high by 7 in. deep) in 5¼ in. of standard rack space. —Computer Control Co., Inc., Framingham, Mass.

Circle No. 353 on reply card

ACCESSORIES & MATERIALS



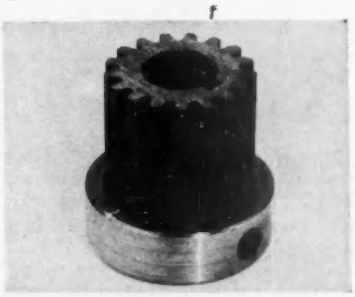
ANALOG PROCESS COMPUTER

A new analog computer that performs any one of the three mathematical functions most common to process control enables electronic systems to perform additional operations. The computer can extract the square root of a single input or ratio or multiply two inputs from a primary transmitter. Output is the accurate analog value for the mathematical function and can be used to operate directly a recorder, indicator, or controller. The unit is designed for back of panel mounting and measures 9⅜ x 12 9/16 x 6⅛ in. Input and output are within 0 to 0.5 vac. Power required: 115 volts. Com-

NEW PRODUCTS

puter is priced at $500.–Swarthout Div. of Crane Co., Manchester, N. H.

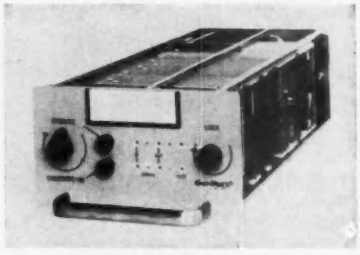
Circle No. 354 on reply card



DENSIFIED WOOD

The gear shown above is made from Lignostone, a densified wood material manufactured in Holland. Either solid or laminated beech blocks are available for a variety of uses including: bearings, connectors, gears, electrical parts, insulators, and even nuclear shields. Harder and stronger than wood or plywood but lighter than metals and easy to machine, the material is available in a wide variety of sheet and block sizes. Price for a 10 x 84 x ¾ in. thick sheet of the laminated type, for example, is $20.–Lignostone Dept., Techno Exports, New York, N. Y.

Circle No. 355 on reply card



CALIBRATES AND CONDITIONS

The Model 1028 provides excitation, calibration, and normalization of the output of virtually any transducer. Reliable and easy to operate, the device eleminates the need for duplicate power supplies, voltage references, enclosures, and controls. Standard printed circuit cards can be interchanged to match various transducer characteristics. – Epsco-West, Anaheim, Calif.

Circle No. 356 on reply card

BULLETINS AND CATALOGS

NOTE: This month's Bulletins & Catalogs section starts with several items for which written requests are necessary. Complete addresses are given for them

ON THERMOELECTRICITY. AMP, Inc., Harrisburg, Pa. A complete bibliography on thermoelectricity, prepared during the past several years by AMP's research engineers, features a critical commentary on each of the articles listed.

FILMS ON SEMICONDUCTORS. Westinghouse Electric Corp., Semiconductor Dept., Youngwood, Pa. (or nearest Westinghouse sales office). Two new slidefilm strips, complete with long-play recorded narrations, are available on a loan basis. Each strip is 15 min long and is ideally suited for training of semitechnical audiences. Films cover principles and manufacture. An illustrated booklet is also available in quantities for distribution to groups viewing the films.

POWER TRANSISTORS. Technical Information Center, Motorola Semiconductor Products, Inc., 5005 East McDowell Rd., Phoenix, Ariz. Power Transistor Handbook, 200 pp, $2. Following up on the well received Zener Diode Handbook, this new book is devoted entirely to power transistor theory, design, and applications. Supplemented with over 200 drawings and charts, plus numerous design problems and solutions, the book serves as a reference as well as an introduction to power transistor applications. Mechanical, electrical, and thermal characteristics, plus maximum ratings are covered in detail.

(400) STRAIN GAGE G-METER Transducer. Div., Consolidated Electrodynamics Corp. Bulletin 4202, 2 pp. Presents design and performance data on the smallest temperature-compensated strain gage accelerometer. Illustrations include photo, circuit diagram, and dimension drawing. Input, output, environmental, and physical specifications are listed.

(401) COMPILER MANUAL. Computer Div., Bendix Corp. Manual T 21, 32 pp. Designed to enable engineers and scientists to master the Bendix G-15 ALGOL compiler, this self-teaching manual describes the language of ALGOL and sets forth the procedures for the representation of numerical data and control statements. Step-by-step examples illustrate the principles and operational characteristics of the compiler.

(402) SUBMINIATURE SWITCHES. Unimax Switch Div., The W. L. Maxson Corp. Catalog No. 20-1, 16 pp. Contains complete information on the expanded line of Unimax subminiature switches including new high-temperature, sealed, environment-free, and MIL-specification types. These are in addition to the popular styles of phenolic-cased, pushbutton, toggle, and integral-actuator subminiature switch models. Catalog also contains convenient pictorial index.

(403) VOLTAGE REGULATOR LINE. Raytheon Co., Commercial Apparatus and Systems Div. Catalog 4-265, 10 pp. Provides complete specifications for more than

2,000 standard magnetic voltage regulator models. A large, two-page foldout chart lists electrical and physical characteristics and simplifies the selection problem.

(404) TRANSDUCERS AND TRANSMITTERS. International Resistance Co., Control Components Div. Control Components Guide, 8 pp. Booklet contains illustrations and complete specifications for the division's product line, which includes military telemetering pressure transducers, high accuracy pressure transmitters, high voltage pressure transmitters and displacement position transducers.

(405) AC TO DC CONVERSION. Adage, Inc. Technical Data Sheet, 4 pp. Entitled "Applications Notes on Ac to Dc Conversion", this data sheet describes in detail the operation and significant waveforms of a newly developed conversion method. A functional block diagram, also included, corresponds to the hardware used to make the conversion.

(406) SERVO ANALYZER. Vought Electronics Div., Chance Vought Aircraft, Inc. Bulletin, 3 pp. Covers the features, performance, and package of an all-electronic servoanalyzer designed for phase and gain response measurements on servosystems, amplifiers, etc. Block diagram illustrates its major components.

(407) SPEED REDUCER BOOK. Link-Belt Co. Book 2719, 36 pp. Describes the company's complete line of "balanced design" parallel shaft speed reducers. Sixteen pages of rating tables contain thermal and mechanical horsepower ratings for each input and output speed. Load classes are shown for almost 250 driven machines.

(408) OPEN HEARTH CONTROL. Hagan Chemicals and Controls, Inc. Bulletin MSA 189, 16 pp. Leads off with a case history of how automatic control systems were applied to 12 open hearth furnaces at Pittsburgh Steel. Goes into such areas as fuel flow control, atomizing steel control, fuel/air ratio control, furnace pressure control, and reversal control. Concludes with a list of five steps which Hagan suggests as a means of fully automating the open hearth process.

(409) TRANSDUCTOR MANUAL. Control Div. of Magnetics, Inc. Manual T-11, 38 pp. Illustrated with charts, diagrams, curves, cutaway drawings, and photos, this manual provides details on the design and operation of the company's static transductors. Publication also outlines typical applications.

(410) ANALYZER ACCESSORIES. Scientific and Process Instruments Div., Beckman Instruments, Inc. Bulletin 738, 14 pp. Covers a wide range of accessories designed for use with Beckman DK spectrophotometers. Equipment described adapts to the requirements of such analyses as flame photometry, fluorometry, reflectometry, spectroradiometry, colorimetry, solid phase studies, reaction rate studies, and turbidity observations.

(411) REMOTE METER READING. Programation Div., Guardian Electric Mfg. Co. Bulletin P 2, 4 pp. Describes the components and operation of a system designed for the remote reading of large

industrial gas meters by telephone. Illustrations include photos and a block diagram showing major system components.

(412) DIFFERENTIAL REFRACTOMETER. Waters Associates. Bulletin, 4 pp. Describes the operation, application, and specifications of a new laboratory recording differential refractometer. Simplified diagram shows the electrical and optical systems involved; table lists available ranges.

(413) PNEUMATIC COMPUTER DATA. Fischer & Porter Co. Catalog 53CR1000, 8 pp. Covers the operation and application of the Sorteberg Force Bridge, a compact pneumatic computing relay. Contains details on each of the computer's operations which include multiplication, division, squaring, square root extraction, square root extraction with pressure compensation, simultaneous multiplication and division, and ratio setting.

(414) SILICONE APPLICATION. Dow Corning Corp. Brochure, 8 pp. Entitled "Silicones Solve Space Age Problems", this new reference describes just a few of the many established applications for silicones in military and commercial aircraft, missiles, and ground support equipment.

(415) SCR PHASE CONTROLLERS. General Electronic Control, Inc. Bulletin No. 6071, 4 pp. Folder describes and illustrates a new line of modular phase controllers and SCR amplifiers. Basic modules can be combined to provide optimum design for power control applications in missiles, rockets, servomotors, and temperature and illumination controls. Center spread shows typical module arrangements, transfer characteristics, outstanding features, and specification charts.

(416) ADJUSTABLE SPEED DRIVES. General Electric Co. Bulletin GEA 6806, 16 pp. Discusses operation and design of the new ¼ to 25 hp line of Polydyne mechanical adjustable speed drives. Also discusses the benefits of such drives and shows how to select and specify Polydyne units.

(417) DIGITAL VOLTMETER GUIDE. Non-Linear Systems, Inc. Folder, 10 pp. This "Pocket Guide to the Proper Selection of Digital Measuring Instruments" covers many of the factors that must be considered when purchasing a digital voltmeter. Last four pages contain photos, brief spec lists, and prices.

(418) SEMICONDUCTOR DATA. Hoffman Electronics Corp., Semiconductor Div. Catalog, 20 pp. Details the company's complete current product line. Contains electrical and physical parameters of Hoffman's silicon solar devices, silicon transistors, silicon diodes, silicon controlled rectifiers, zener regulators, and zener reference devices.

(419) PANEL METERS. Helipot Div., Beckman Instruments, Inc. Data Sheet 601, 4 pp. plus price list. Lists 92 standard models of Beckman voltmeters, ammeters, milliammeters, and microammeters in each of three sizes. Photos and dimension drawings illustrate typical meters in each size.

(420) PHOTOELECTRIC CONTROLS. Autotron, Inc. Catalog 60, 24 pp. Describes the latest developments in high speed, ultra sensitive, and impulse actuated controls; tubeless photoelectric con-

Bulletins & Catalogs

trols; safety controls; photoelectric and electronic timing controls; controls with built-in, remote, and subminiature sensing heads; and plug-in mounted controls. Also covers a wide selection of light sources.

(421) DATA PROCESSING SYSTEMS. Friden, Inc. Booklet, 28 pp. Presents information on the function and application of most of Friden's tape operated machines: Flexowriter, Computyper, Teledata, Collectadata, and Selectadata. Also covers a variety of auxiliary input-output equipment.

(422) PORTABLE RECORDERS. Brush Instruments Div., Clevite Corp. Catalog 2500/760, 4 pp. Illustrated brochure describes the Brush Mark II portable direct-writing recorders, including both electric and ink writing types. Discusses the choice of either ink or electric writing for specific applications and the type of data that can be recorded on the four available channels.

(423) MULTITUBE DATA. Crescent Insulated Wire & Cable Co. Bulletin No. 960, 12 pp. Contains complete information on spirally cabled tubes for instrument and control systems. Details cover the various types of tubing available, the protective interlocked metallic armor, types of corrosion-resistant sheaths, as well as instructions for installation.

(424) PRESSURE PICKUPS. Servonic Instruments, Inc. Bulletin S-606, 2 pp. Describes two new ac pressure transducers of the induction potentionmeter type. Bulletin provides complete electrical, mechanical and dimension data for both models.

(425) ELECTRONIC CONTROLS. Barber-Colman Co. Data Sheet F-9754, 4 pp. Lists and describes a complete line of electronic package control sets specifically designed for temperature control of valve-type unit ventilators.

(426) GAGE INSTRUMENTATION. Measurement Control Devices, Sub. of Schaevitz Engineering. Catalog No. G-100, 4 pp. Illustrated brochure describes in detail the systems and components available for the continuous indication and monitoring of minute changes in dimensions for control purposes. Display units for use in closed-loop servo indicating systems are also described.

(427) PRECISION TRANSDUCERS. Instrument Div., Bourns, Inc. Summary brochure No. 2, 20 pp. Handy reference contains basic specifications on pressure transducers, motion transducers, accelerometers, and precision potentiometers, including 13 new products. Brochure also briefly describes the company's engineering, production, quality control, and environmental testing departments.

(428) SUPERVISORY INSTRUMENTS. General Electric Co. Bulletin GEZ-307A-1, 12 pp. Deals with the company's compact redesign of a turbine supervisory instruments system that charts a permanent record of mechanical performance throughout the starting and running periods. Details cover the system's ability to monitor vibration, shaft eccentricity, shell and differential expansion, speed, and valve position.

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- **Basics of Hot Gas Control Systems**
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  Transistorized tool-control unit gives both circular and linear interpolation.
- **Multiple Columns in Chromatography**
  More than one column speeds analysis, improves resolution, and protects equipment.
- **Nonlinear Controller Stops Train Accurately**
  Unique Japanese multimode control stops electric train within 4 in. of desired point.
- **17 Ways to Measure Acceleration**
  An authority summarizes many of the ways to measure acceleration in sketches and captions.
- **Predicting Performance of Metering Pumps**
  Derived figure of merit is useful in predicting metering pump performance.
- **Computer Controls Job Shop Production**
  Aircraft manufacturer cuts inventory and lead time by consolidating paper work and employing a computer.

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Bulletins and Catalogs

9. ACCESSORIES AND MATERIALS

Advertisements

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CONTROL BITS

Second step for man-in-space in the U. S., after project Mercury, is Project Apollo, a versatile spacecraft that will permit manned reconnaissance to the vicinity of the moon. NASA has selected three contractors to conduct individual feasibility studies. The threesome: Convair, GE, and the Martin Co.

•

Five British companies have formed an international consortium to market an air-to-ground multichannel telemetry system. System is claimed to have a range of 100 miles in line of sight, operates in the ultra high frequency range of 400 to 418 Mc.

WHAT'S NEW

(Continued from page 50)

Computer Dept. moved toward a full line of computer products with the announcement that it had set up an engineering group to develop a line of peripheral equipment.

The group will be responsible for developing all computer accessory equipment comprising integrated data processing systems.

IBM's 'Little Card' Machine Outselling Hotcakes Abroad

Ask an American computer expert about an IBM 3000 machine and the result will probably be a blank look. But in foreign markets—where this inexpensive punched card accounting system is sold exclusively—the 3000 is selling at a rate that excites even ultra-businesslike IBM executives. Rental: $340 per month.

Designed and built by IBM World Trade Corp.'s subsidiary, IBM Germany, the 3000 was first announced at the Hanover (Germany) Fair last May. Since then almost 800 of the systems have been leased or sold. After one display in Japan, two months ago, IBM wrote at least 40 orders. The startling prospects: IBM World Trade now confidently predicts sales of 6,000 systems in Europe alone within the next five years.

An innovation to IBM in the 3000 is the unusual card format: half the size of the standard IBM card, with round holes that still allow the full 80-column capacity.

The small card is responsible for the low price and compactness of the 3000 units. The complete accounting system consists of three units: a punch/verifier the size of a typewriter, a sorter that takes less space than one 4-ft shelf of books, and an accounting machine about the size of a 4-ft high, 4-ft wide bookcase.

Cards are punched by the 3000 at a rate of 90 per min. Maximum speed of multiplication is 1,800 cards per hour; for division, maximum of 1,080 cph. The sorter handles 460 cpm; storage: 30 characters.

No plans are being made to market the 3000 in the U. S.

Japan on Brink of World Competition in Computers

TOKYO—

The spectre of low cost competition in computers from Japan edged a step closer to reality last month—close enough, according to some observers, that the path of Japanese par-

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WHAT'S NEW

ticipation in the world's computer market was sure to be set very soon.

Strongest ingredient to be thrown so far into Japan's bubbling computer cauldron has been IBM's deal with the government's Ministry of International Trade and Industry. IBM is to set up a Japanese computer combine in which it would contribute its punched card equipment know-how in exchange for 90 percent ownership and guaranteed remittable royalties (see CtE, Oct. '60, p. 46).

Now Remington Rand is attempting to cut itself a piece of the booming industry with plans to set up a manufacturing and marketing company in Japan. And on top of this, MITI is thinking of reactivating its three-year-old plan for a nationalized computer company.

Rem Rand's plan calls for a joint-venture company involving its affiliate, Remington Univac Japan, along with Mitsui Kaisha Bussan—Japan's largest trading company, and Tokyo Shibaura (Toshiba)—a GE affiliate (about 7 percent GE owned) and Japan's largest electronics manufacturer. Rem Rand would feed the group computer know-how that it has rights to under an IBM cross-licensing agreement.

• **Ownership impasse**—Under these licenses IBM and Rem Rand are allowed nonexclusive rights to make and sell each other's data processing equipment that was under patent as of October 1, 1956. And each firm is allowed to pass the rights on to their subsidiaries. But here's the catch: "subsidiary" is defined in the agreement as a firm owned more than 50 percent by either company; and Rem Rand owns only 30 percent of Remington Univac Japan (Mitsui owns 50 percent, Toshiba the rest).

Negotiations are stuck now on MITI's reluctance to allow majority foreign ownership. The only way out some observers see is for MITI to relent and allow Mitsui to relinquish enough of its holdings to Rem Rand to give it majority control. As this issue went to press. Univac Japan had opened the first foreign owned computer center in downtown Tokyo and was sure Mitsui would concede some of its share.

• **Enter the government**—Into all this last month also stepped the possibility of a nationalized computer industry. Capitalized at $6 million—half from the government and half from industry—the national electronic computer company would resemble similar setups existing in the atomic energy and aircraft fields.

MITI's planned company would promote Japanese electronics industry as a whole and push computer making. It would cover the individual manufacturers' losses and purchase their output of small computers and rent them. Rentals would grow from a goal of 60 units in 1961 to 250 in 1966. Revenue would be $1 million the first year with a $700,000 deficit. But by 1966 revenue is projected up to $30 million with a $1.8 million profit. Under the current plan the proposed company would also do research and development on large scale computers.

News of Other Companies In the Control Field

Clauser Technology Corp., a new firm to engage in development and production of electronic equipment and instruments, has been formed in Torrance, Calif., by Dr. Milton U. Clauser. Assisting in the formation of the company was the venture capital firm of Draper, Gaither & Anderson.

Briggs Associates, Inc. of Norristown, Pa. has agreed upon a plan for merger with Vanguard Air and Marine Corp. of Paoli, Pa. The merger proposal will be submitted to stockholders. Briggs is engaged in electronic development and has installed automatic control systems in industrial plants and military laboratories.

GE's Defense Systems Dept. has established a Space Systems Operation in Santa Barbara, Calif. The setup will be managed by B. G. Walker.

FXR, Inc. of Woodside, N. Y., has entered into a mutual licensing agreement with Elliott Brothers (London) Ltd. The pact gives the two companies exclusive rights to manufacture and sell each other's range of microwave components and instruments.

Telecomputing Corp., Los Angeles, has made its first move toward expansion on the east coast with the acquisition of Computer Sciences, Inc. of Westbury, N. Y.

United Aircraft Corp., E. Hartford, Conn., has acquired a 20-per-cent interest in Societe Pecilec, an electronics company in Paris, France, and one-fifth part also in Societe Somalec. Arrangement was made in behalf of UAC's Norden Div.

American Society of Mechanical Engineers has changed to Automatic Control Div. the name of its Instruments and Regulators Div.

WHAT'S NEW

IMPORTANT MOVES BY KEY PEOPLE

Orpin With Stromberg-Carlson Again; Heads San Diego Unit

After a year's absence, L. H. Orpin has rejoined Stromberg-Carlson, this time as general manager of its San Diego (Calif.) facility. Orpin had previously been director of plans and programs at Stromberg-Carlson's main plant in Rochester, N. Y. His year away from the firm was spent at RCA where he was a manager of planning.

In his new position Orpin will be responsible for all operations of S-C-San Diego, which produces the Charactron shaped beam tube, high speed electronic printers, readout and display devices, and military gear.

Orpin's background previous to first joining S-C included positions in the Radiation Laboratory at MIT, General Railway Signal Co., Fairchild Guided Missile Div., and Convair, which is along with S-C a division of General Dynamics Corp.

Schaevitz Names Dr. Miller Head of New Dept.

Schaevitz Engineering, Pennsauken, N. J., has chosen Dr. Juls Miller to head its newly announced Electromagnetic Devices Dept. The new venture for Schaevitz will include the design and production of fractional and subfractional motors, converters, transformers, generators.

Motors to be included in the new line will range from 1/3000 to 1 hp and will carry price tags from $10 for small, simple units up to $300.

Dr. Miller, who invented the first radio timer, was formerly with Schick Electric Shaver Co. as chief of the motor department which developed the first reciprocating shavers. He has also been with Lamb Electric Co. and the Decker Corp. in the past 25 years.

Prior to coming to the U. S., Dr. Miller was professor and chief of engineering at Depoge College, Berlin, Germany, and also was editor-in-chief of a Berlin electrical magazine. During World War II Dr. Miller instructed U. S. soldiers in motor design and repair.

Ampex Planning Engineer Joins Data-Control Systems

New assistant to the president of Data-Control Systems, Inc., Danbury, Conn., is Roy W. Pyburn. Pyburn joins DCS from Ampex Corp. where he was senior product planning engineer for the past four years. He was responsible for market research and evaluation of future requirements for Ampex's field.

Pyburn worked for nine years in the Civil Aeronautics Administration (now FAA) as a supervisory electronics specialist. He was concerned with installation and testing of airways communications systems and radars. He then joined Boeing Airplane Co. where he developed Bomarc test equipment.

Ogletree New Manager At Computer Systems

W. A. Ogletree has joined Computer Systems, Inc. as the company's new general manager. Ogletree's previous position was at the Burroughs Corp., where he was manager of engineering for the Military Electronic Computer Div.

Previous to joining Burroughs in 1953 at its Research Center, Ogletree served for a year on a British missionary board developing broadcasting and communications equipment. He also spent a period for the U. S. Coast Guard working on the development of LORAN.

Computer Systems in Monmouth Junction, N. J., manufactures analog computers, missile range instrumentation, and computer accessories.

Other Important Moves

Dr. Donald W. Collier has been named by Borg-Warner Corp. to the new post of vice-president for research. Dr. Collier has been president of the

Thomas A. Edison Research Laboratory Div. of McGraw-Edison Co.

John B. Montgomery has become the president of Daystrom, Inc., as Thomas Roy Jones was elevated to chairman of the board. Montgomery comes to Daystrom from GE's Flight Propulsion Div. where he was vice-president and general manager. Jones will continue as chief executive officer of the firm.

Clarence H. Hopper has become the president of CBS Electronics, the Danvers (Mass.)-headquartered division of the Columbia Broadcasting Systems, Inc.

Dr. Robert Britton is now director of military engineering for Airtronics International Corp. in Ft. Lauderdale, Fla. Dr. Britton was most recently project engineer in charge of test facilities for Electronic Communications.

Dr. Alan J. Rowe has taken the post of manager of research in Hughes Aircraft Co.'s industrial dynamics department, Culver City, Calif. Dr. Rowe was director of management control systems research at Systems Development Corp.

John A. Wiedmann has joined the industrial division of Hydromatics, Inc. as chief engineer. The Bloomfield, N. J., firm makes Flo-Ball trademarked valves. Wiedmann was formerly chief design engineer for Honeywell's Missile Equipment Div.

George B. Robbins is the new general manager of the Electronics Div of Fairbanks, Morse & Co. in W. Hartford, Conn. Robbins has taken over from John S. Tompkins, who organized the new division and supervised its transfer to its new location.

Obituaries

Dr. W. R. G. Baker, 67; president of Syracuse University Research Corp.; former chairman, executive committee, Gulton Industries, Inc.; former vice-president, General Electric Co.; former vice-president and general manager, RCA Victor Corp.; pioneer in radio, TV, and radar communications; after a short illness in Syracuse, N. Y., Oct. 30.

Harry H. Goode, 51; professor of electrical engineering, University of Michigan; taught U. S.'s first course in systems engineering; as the result of an automobile accident in Ann Arbor, Mich., October 30.

ABSTRACTS

Hall Effect Transducer

From "Electric Displacement Transducer Applying Hall Effect", by Isamu Ohno. Journal of the Society of Instrument Technology, Japan, September 1960, pp. 549-558. In Japanese.

When a magnetic field is applied vertically to the direction of a current running through a crystal of semiconductor material, a gradient of potential appears at a right angle both to the field and the current. This phenomenon is called the Hall effect. The electrical displacement transducer, used as a detector of Yokogawa's new electronic control system, employs the Hall effect of a germanium pellet inserted into a nonuniform magnetic field. When the pellet moves right or left, the Hall voltage changes by the increase or decrease of magnetic flux which is interlinked to the pellet.

The relation of displacement and Hall voltage depends on the shape of the pellet and the distribution of the magnetic flux. In the transducer the pellet is sealed within a metal capsule so as not to expose it to open air, and the temperature distribution of the pellet is maintained uniform. Tests on 0.3 ohm-cm N-type germanium showed that the Hall voltage remained within 0.5 percent of nominal over the temperature range from minus 40 to plus 95 deg C.

The transducer output is 10 mv. for a 2-mm displacement, with a nonlinearity of less than 0.3 percent.

Body measurements

From "A Pragmatic Approach to Bio-Instrumentation", by S. U. Miller, N. S. Namerow, and P. G. Strauss, Space Systems and Industrial Automation, Inc. Paper No. 230K sponsored by the Society of Automotive Engineers for presentation at the SAE-AFOSR Astronautic Symposium, Los Angeles, Oct. 12-14, 1960.

As the following list of biological functions and their measuring techniques indicate, certain limitations on monitoring become quite obvious. As examples, there are at present no convenient or accurate methods for continuously measuring blood pressure, blood flow through specific organs or regions of the body, cardiac output, hormone or enzyme levels, cellular behavior, radiation effects, physical and mental stress, and pain. The authors, all medical doctors, have

embarked on a program to identify and develop techniques for detecting and quantifying some of these elusive physiological phenomena.

Respiration depth and rate—
- strain gage and thermocouple

Cardiac rate—
- direct electrical input, microphone, and strain gage

Blood pressure—
- strain gage and microphone

Electrical activity of the heart—
- direct electrical input

Electrical activity of the brain—
- direct electrical input

Electrical activity of somatic muscle—
- direct electrical input

Ocular movement—
- direct electrical input

Oxygen saturation of blood hemoglobin—
- photoelectric photometer

Skin resistance—
- electroresistive bridge

Body temperature—
- thermistor

Alveolar pCO_2—
- infrared CO_2 analyzer (capacitance membrane pressure transducer)

Metering chemical flow

From "Development of Agent Flow Measurement Methods", by R. L. Hough and W. R. Kane, Aeronautical Accessories Lab., Wright Air Development Div., U. S. Air Force. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. as PB 161726, 46 pp., $1.25.

A highly refined phase-change indicator, which can measure initial velocity and average flow rate of chemical agents, has been developed for use in aircraft fire extinguishing systems. The device is also applicable to transient flow hydrodynamic systems. Several instrument techniques were developed, engineered, and tested.

Simplifying multiloops

From "A Contribution to the Theory of Multiple Loop Control Systems", by C. Kessler. Regelungstechnik, August 1960, pp. 261-266. In German.

Automatic controls are expected to satisfy so many diverse requirements that it is frequently necessary to design multiple loop systems to meet all demands. The author describes a method of calculating multiple loop systems by the cumulative use of the known sizing rules for single loop control systems. By stepwise structural transformations, multiloop systems can be converted into single loop control systems of the same kind.

NEW BOOKS

Symposium report

INFORMATION AND DECISION PROCESSES. *Ed. by Robert E. Machol, Purdue University.* 185 *pp. Published by McGraw-Hill Book Co., Inc., New York.* $5.95.

This book contains papers presented at the 1959 and 1958 symposiums on information and decision processes held at Purdue. The speakers represented in this volume (10 from the 1959 meeting and two from 1958) have in some cases modified their papers or rewritten them entirely to fit the content of the publication.

Nine of the contributors are mathematicians, and the other three—an economist, a philosopher, and an electrical engineer—have become known also as mathematicians. Papers range from "Computation in Decision Making" to "On Some Aspects of Models of Complex Behavioral Systems".

Editor Machol has written an excellent introduction, reviewing the past two decades in the field and passing on to the reader some of the excitement the work holds for himself.

The book's quality suffers from the fact that, instead of being set in regular type, its pages consist of reproductions of the typewritten papers, with even some handwritten symbols.

New transistor handbook

GENERAL ELECTRIC TRANSISTOR MANUAL, *J. R. Lowry et al.* 329 *pp. Published by General Electric Co., Liverpool, N. Y.* $1.

This new edition of a familiar manufacturer's design handbook contains updated material including new chapters on test circuits, feedback and servoamplifiers, tunnel diode theory and switching circuits, and tunnel diode amplifiers. Over 200 JEDEC transistor types have been added with closest GE type applicable indicated.

Valuable recapitulation

TEMPERATURE MEASUREMENT AND CONTROL, *W. F. Coxon.* 314 *pp. Published by Macmillan Co., New York.* $12.00

Temperature measurement proves necessary in virtually every industrial, military, space, and research endeavor. As an example of the importance of this variable, a survey made some years ago by CONTROL ENGINEERING showed that 91 percent of the respondents made temperature measurements and that of these between 16 and 25 percent devoted over one-half of their

measurement activity time to temperature determinations.

Thus, while temperature measurement is by no means "new", it is much used. Therefore a good book on this subject should have immediate and lasting value for a large number of control engineers. Dr. Coxon has produced such a book.

Over the years the many ramifications in temperature-measurement cations grew into an engineering specialty, and like other specialties this one requires scientific knowledge tempered by experience (art, witchcraft) for its successful practice. All these factors the author has brought to his book.

In choosing the content, Dr. Coxon has relied on other (primarily British) publications on this subject, a matter which he acknowledges in the preface. To his credit is the way in which he has selected, integrated, and organized the subject matter with outstanding technical and literary craftmanship, thereby contributing a most worthwhile basic text and reference on the subject of temperature measurement and control.

Typical of the content are such chapters as significant preliminary data on heat, the classification and choice of the temperature measurement method, thermocouples, resistance thermometers, measurement of high temperatures, automatic temperature control, and temperature measurements in practice. The volume is replete with useful tabulated information. HRK.

Useful reference

ELECTRONICS AND NUCLEONICS DICTIONARY. *Nelson M. Cooke, Cooke Engineering Co., and John Markus, McGraw-Hill Dictionary Dept. 543 pp. Published by McGraw-Hill Book Co., Inc., New York.* $12.

A revision of the 1945 book by the authors, *Electronics Dictionary*, this new work contains definitions of more than 13,000 terms used in the electronics and nucleonics fields. In addition, over 450 illustrations clarify meanings of complex terms, and some circuits—with circuit values—are even starting points for design.

Definitions are based on standard terms as approved by IRE, AIEE, and ASA and also include terms not in use 15 years ago, as in space technology, underwater electronics, and others. Since it clears up questions of trademarks, spelling, hyphenations and follows a consistent policy on compound words, the dictionary can be used as a style manual for checking terms in reports, contracts, catalogs, etc.

MEETINGS

DECEMBER

Eastern Joint Computer Conference, sponsored by IRE, AIEE, ACM, Hotel New Yorker and Manhattan Center, New York. Dec. 13-15

Symposium on Combined Analog Digital Computer Systems, sponsored by Simulation Councils, Inc. and General Electric Co., Sheraton Hotel, Philadelphia, Pa. Dec. 16-17

JANUARY

Symposium on Thermoelectric Energy Conversion, sponsored by IRE, AIEE, et al, Statler Hotel, Dallas, Tex. Jan. 8-12

Seventh National Symposium on Reliability and Quality Control, sponsored by IRE, AIEE, ASQC, EIA, Bellevue-Stratford Hotel, Philadelphia, Pa. Jan. 9-11

16th Annual Symposium on Instrumentation for the Process Industries, Texas A&M College, College Station, Tex. Jan. 26-28

American Institute of Electrical Engineers, Winter General Meeting, Statler-Hilton Hotel, New York Jan. 30-Feb. 3

FEBRUARY

Institute of Radio Engineers, Second Winter Military-Electronics Convention, Biltmore Hotel, Los Angeles, Calif. Feb. 1-3

Eighth Annual International Solid-State Circuits Conference, sponsored by IRE, AIEE, and University of Pennsylvania, University of Pennsylvania campus and Sheraton Hotel, Philadelphia, Pa. Feb. 15-17

MARCH

Instrument Society of America, 11th Annual Spring Conference on Instrumentation for the Iron and Steel Industry, Roosevelt Hotel, Pittsburgh, Pa. March 8-9

Institute of Radio Engineers, International Convention, Coliseum and Waldorf Astoria Hotel, New York, N. Y. March 20-23

American Society for Metals, 13th Western Metal Exposition and Congress, Pan Pacific Auditorium, Los Angeles, Calif. March 20-24

Temperature—Its Measurement and Control in Science and Industry, sponsored by American Institute of Physics, ISA, and National Bureau of Standards, Columbus, Ohio. March 27-31

WHAT'S AVAILABLE IN REPRINTS

The following reprints have been prepared to make important reference-type editorial material available to CONTROL ENGINEERING readers in convenient filable form. Single copies of any reprint can be obtained at the nominal cost listed below by circling the corresponding numbers on a reader service card, p. 167. Don't send money with card, we will bill you later. For multiple copies write Reader Service Dept. Quantity rates will be quoted on request.

506—What You Should Know About Adaptive Systems, 17 pp. Is there such a thing as an adaptive control system? What approaches have been taken? What does the future hold? These are the questions the author answers in this three-article reprint, in sufficient detail and with sufficient references to provide a basic grounding in this latest area of control engineer interest. 50 cents.

505—The Basics of Optimum Response Relay Servos, 17 pp. Three part series summarizes all of the important design techniques that have been used to optimize the response of relay servos. The reprint describes the development of the optimum switching criteria, and outlines the progress that has been made in implementing this theory with hardware for second-order and higher-order systems. Extensive references provide a guide for further study. 50 cents.

504—System Characteristics of Modern Guidance Techniques, August 1960, 22 pp. In this special report five experts from three companies cover the system characteristics of inertial navigators, guidance radars, Doppler radar techniques, modern techniques in celestial navigation, and perceptive guidance systems. 65 cents.

503—How to Determine Stream Analyzer Dynamics, 8 pp. This package of two articles shows how analyzers can introduce dynamic errors, how to determine analyzer dynamics, and how to improve performance. The instrument used is a differential refractometer but techniques can be extrapolated to other types of analyzers. 40 cents.

502—Survey of Dynamic Display Techniques, 20 pp. The function of these newly developed techniques is to put up-to-date information in the hands of human operators of control systems when the information changes at a high rate. Both basic approaches and commercial hardware are discussed for cathode ray tube displays, optical systems, and miscellaneous

(Continued on page 187)

devices ranging from TV pickup to matrix cells. 50 cents.

501—Six Transducers for Precision Position Measurement, May 1960, 6 pp. Explains operation and gives practical application hints for six precision position transducers: pin-and-pawl mechanism, magnetic bench-mark system, resolver-type transducer, electrostatic transducer, coded-disc devices, and diffraction gratings. 30 cents.

500—Ready Reference Data Files—I, II, III, 76 pp. The feature here is a special rate for those who purchase all of the Data Files published in CONTROL ENGINEERING through April 1960. The 36 articles included in this package cover analysis, design, and application short-cuts for all phases of the control field. Everyone can use this timeless reference material. $1.35.

499—Ready Reference Data Files—III, 28 pp. Includes the third dozen Data Files published in CONTROL ENGINEERING. Topics range from control of metal properties with eddy currents to electrically signaled valve actuators to stabilization of sampled data systems. 60 cents.

498—Ready Reference Data Files—II, 24 pp. Includes the second dozen data files published in CONTROL ENGINEERING. Topics covered range from analyzing hydraulic servos graphically to using silicon diodes as protective devices. 50 cents.

497—Ready Reference Data Files—I, 24 pp. A must for every control engineer's library. Includes the first 12 data files published in CONTROL ENGINEERING—a diversity of topics from system reliability through the cost of industrial temperature-measuring systems. Each one gives a method of solving a particular problem. 50 cents.

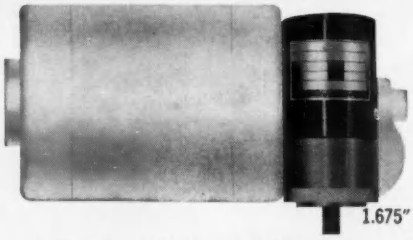
496—How to Specify Instrument Accuracy, 8 pp. This basic reprint is aimed at helping the user and maker to develop clear and mutual agreement on allowable instrument errors. Discussions of uncertainties of zero, scale factor, and instantaneous slope aid in the intelligent specification of allowable errors and preferred test procedures. 40 cents.

495—Transparent Template for Designing Servo Compensators, November 1959, 3 pp. plus template. Includes transparent decibel vs phase angle template on clear acetate in addition to three-page Data File outlining development of template and showing its use through sample problem. 75 cents.

494—How to Use the Root Locus in Control System Design, 12 pp. Another reprint that translates theory into practice. Eight simple rules make locus construction easy, even including the effects of distance-velocity lags. Articles show how to interpret the locus diagram, how to determine transient response, and how to use locus techniques with multiloop systems. 45 cents.

493—Complete Analysis Instrumentation Series, 112 pp. Special rate for those who order all three parts (I, II, and III) of Analysis Instrumentation Series: 17 per-

(Continued on page 189)



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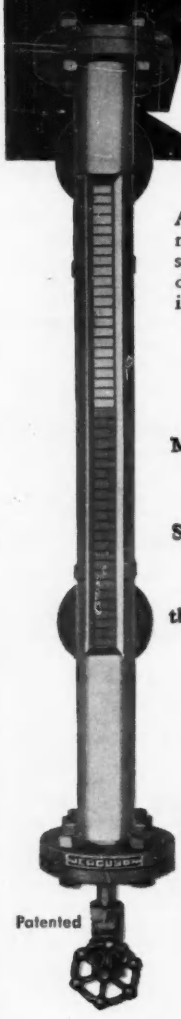

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492 – Analysis Instrumentation – III – Electrochemical Methods, Mass Spectrometry, Continuous Viscometers, X-Ray Techniques, K-Capture, Physical and Chemical Property Testers, Emission Spectroscopy, 48 pp. Reprint includes last nine articles of Analysis Instrumentation Series. 90 cents.

491—Analysis Instrumentation—II—Refractometers, Infrared Analyzers, Ultraviolet Analyzers, Colorimetry, 32 pp. This includes the second group of four articles of the Analysis Series. 60 cents.

490—Analysis Instrumentation—I—Nuclear Magnetic Resonance, Chromatography, Radioactivity, 32 pp. Reprint consists of first 4 articles of Analysis Instrumentation Series: a general introduction and detailed discussions of the three analysis techniques. Emphasis is on basic principles, practical tips, and the use of these techniques in automatic process control. 60 cents.

489—Fundamentals of Multivibrators, 12 pp. Multivibrators are the electronic equivalent of the double-throw electromechanical relay and can perform substantially the same functions (memory, logic, gating, counting), but at enormously higher speeds. They can be built around vacuum tubes, transistors, square-loop magnetic materials, neon tubes, thyratrons, and cryotrons. This reprint covers a broad selection of multivibrator circuits. 45 cents.

488—A Roundup of Control System Test Equipment, 24 pp. Specialized control system test equipment divides into three classes: 1) devices that only generate a test signal, 2) systems that both disturb the system and provide a means for evaluating response, and 3) devices that only evaluate control system response. 60 cents.

487—Survey of Ac Adjustable-Speed Drive Systems, June 1959, 16 pp. Regarded as constant speed devices, multispeed ac actuators actually take many efficient forms. The recent resurgence of interest in these ac adjustable-speed systems prompted this comprehensive coverage of pole-changing techniques, armature resistance control of wound-rotor motors, frequency changing, slip-frequency injection, and the use of eddy-current couplings. 50 cents.

486—A New Way to Select the Best Control Valve, 16 pp. This three-article reprint takes a fresh look at the problem of specifying process flow control valves. The author gives rules for selecting the right valve characteristics based on static and dynamic considerations, takes into account the influence of piping on valve performance, and tackles the problem of sizing valves for maximum flow and for control rangeability. 50 cents.

485—Fundamentals of Tie-Motor Control, 12 pp. Although high powered synchro-tie systems have been around for a long time, only recently has enough

(Continued on page 191)

REPRINTS cont'd

experience been logged to put their design on a scientific, rather than cut-and-try basis. This reprint examines the types of motors that can be used in the light of the application characteristics, and considers the special circuit designs that are required. 30 cents.

484—Applying Phase-Plane Techniques to Nonlinear System Design, 16 pp. This series of three articles is designed to teach the use of phase-plane techniques to working system designers, on a practical rather than theoretical basis. It tells how to construct a phase-plane plot, interpret a plot in terms of system performance, and synthesize nonlinear systems using phase-plane techniques. 50 cents.

483—Economics in Control, December 1958, 24 pp. A special report covering the economic aspects of modernizing with control systems. It starts off with a guide to the financial factors of modernization, then tells the control engineer how to spot opportunities where the addition of instrumentation and control equipment will earn money, and concludes with nine case histories showing specific benefits of modernizing with control systems. 50 cents.

482—Static Switching Devices—New Tools for Industrial Control, May 1957, 28 pp. An independent consultant analyzes the complete field of industrial static-switching systems. Starting off with a review of basic switching logic, he covers circuit characteristics of the fundamental devices, commercially-available systems, actual applications, etc. 50 cents.

480—Selecting and Applying Control Timers, 24 pp. A compilation of four articles including a tabular description of timer functional parts, criteria for selecting and applying control timers, a tabular listing of available timer types and their characteristics and techniques for custom-designing controls for time-based routines. 50 cents.

478—Servo Modulators—Their Application, Characteristics, and Availability, 36 pp. A group of four integrated articles covering all phases of electromechanical, electronic solid state, and magnetic modulators. Typical circuit diagrams, characteristics, and applications are given for each type, plus an 84-item bibliography and tables listing commercial units. 65 cents.

477—Basic Data on Process Control, 24 pp. A grouping of five articles on flow-process control, including Basic Concepts of Feedback Control, Selecting Loops for Critical Control, Direct or Reverse Controller Actions, Modifying Valve Characteristics to Fit the Process, and Using Capacitance for Accurate Level Measurement. 50 cents.

476—How to Simulate Dead Time, 6 pp. Three tricky techniques for simulating dead time or transport lag. One's electronic, another is pneumatic mechanical, and the third uses magnetic tape. A useful reference for control engineers concerned with process simulation. 15 cents.

• • •

EMPLOYMENT OPPORTUNITIES

The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

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Of Control Engineering, published monthly at Albany, New York for October 1, 1960.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Published by McGraw-Hill Publishing Company, Inc., 330 West 42nd St., New York 36, N. Y.; Editor, William E. Vannah, 330 West 42nd St., New York 36, N. Y.; Managing editor, Byron K. Ledgerwood, 330 West 42nd St., New York 36, N. Y.; Business manager, Wallace C. Carmichael, 330 West 42nd St., New York 36, N. Y.

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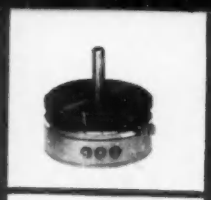

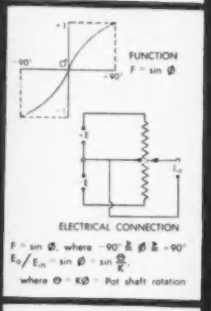

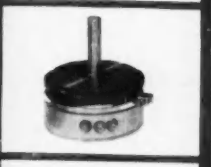

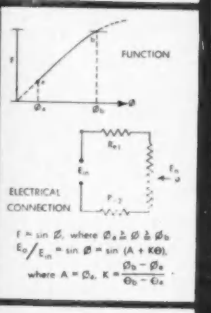

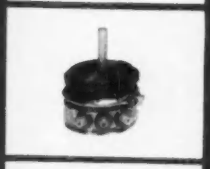

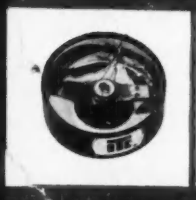

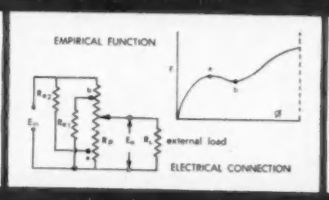

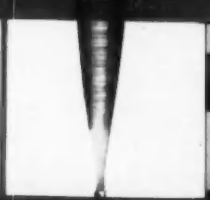

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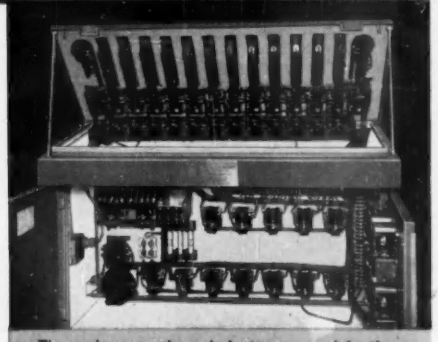

The relays and push buttons used in the remote control console of this M. E. Cunningham Marking Machine are all standard Allen-Bradley catalog items.